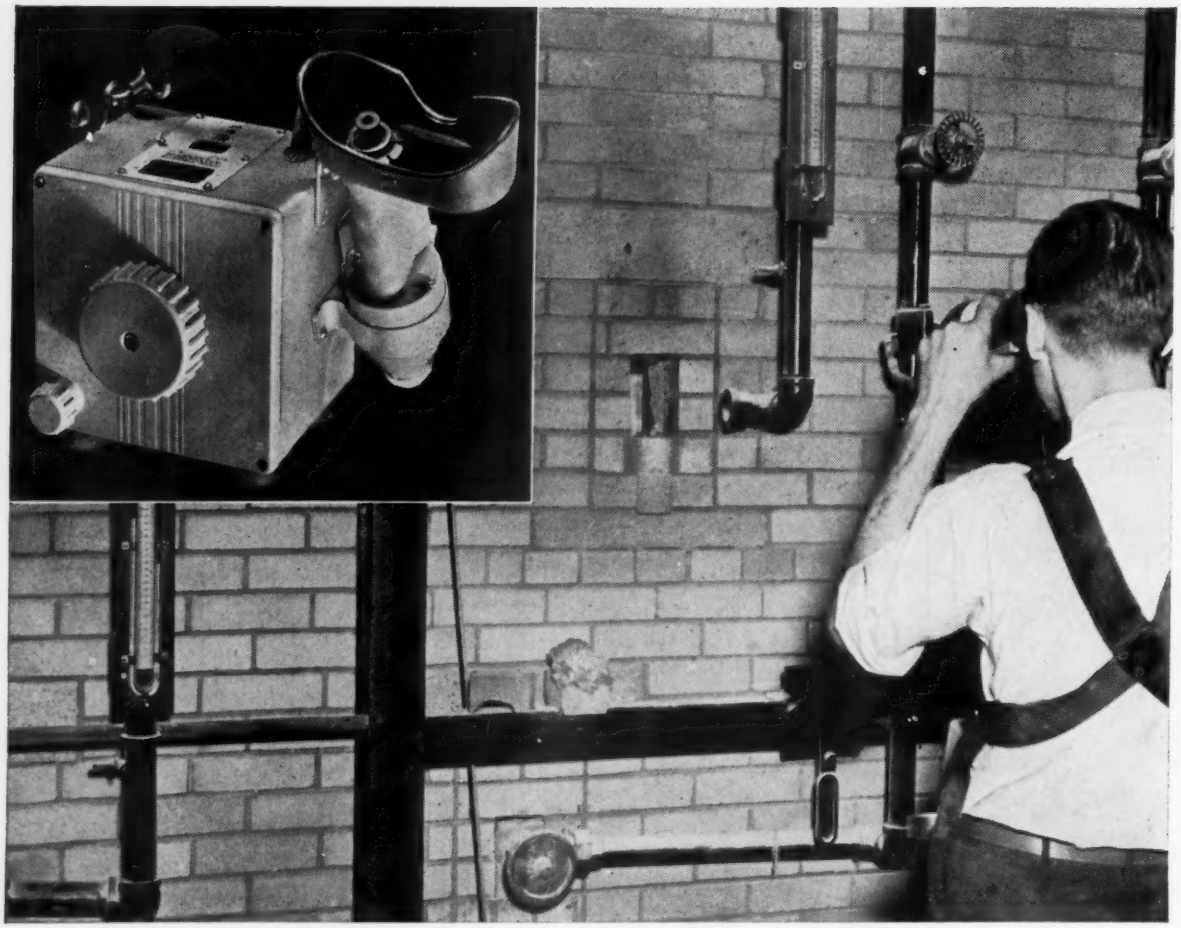
CERAMIC ABSTRACTS and THE BULLETIN

OF THE

AMERICAN CERAMIC SOCIETY

DECEMBER 15, 1944

MONTHLY PUBLICATION DEVOTED TO THE ARTS AND SCIENCES RELATED TO THE SILICATE INDUSTRIES



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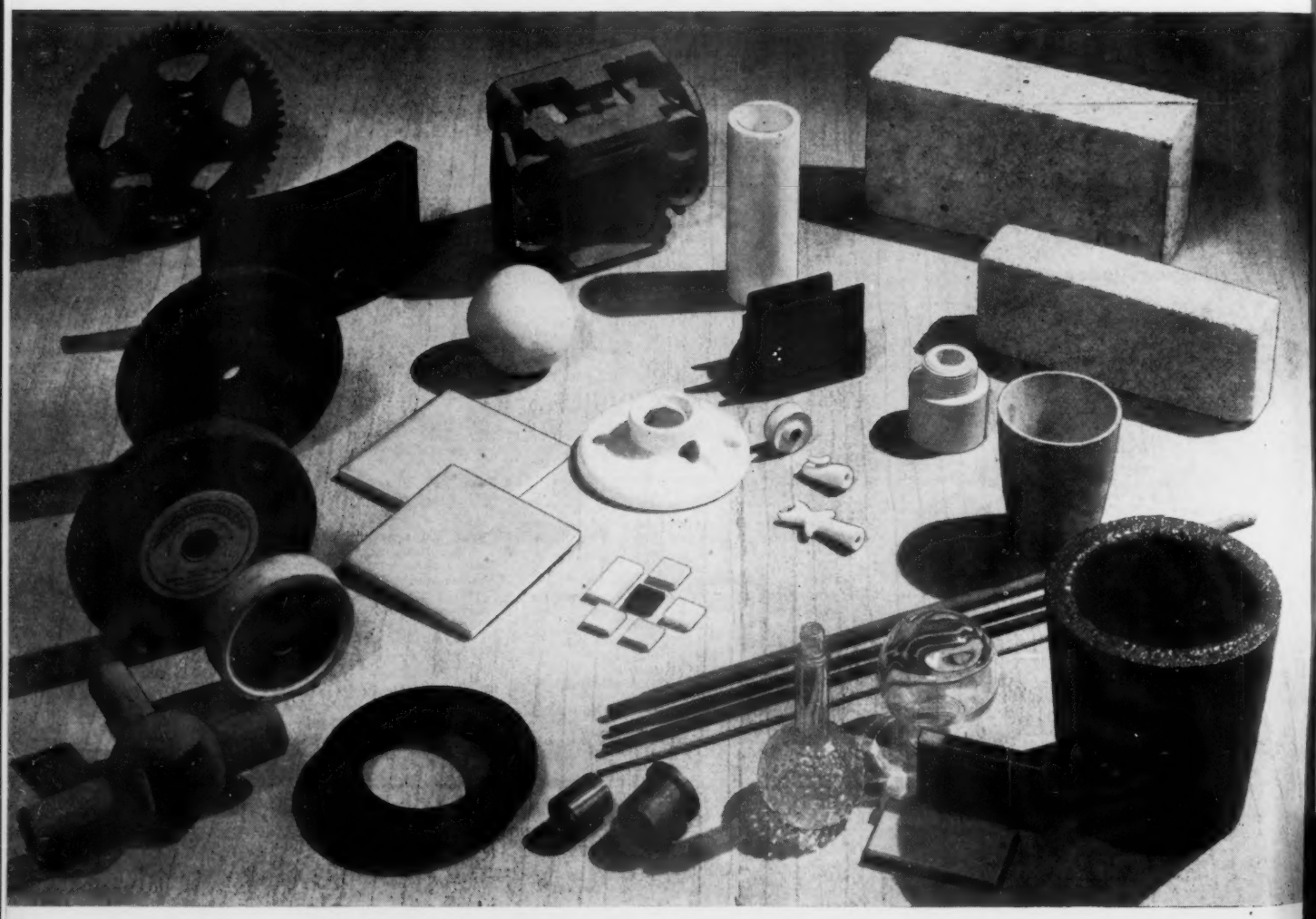

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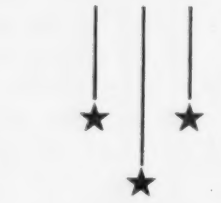

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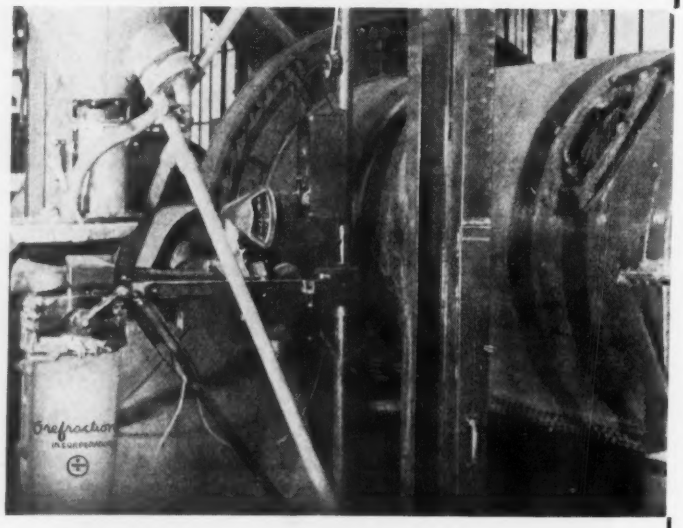

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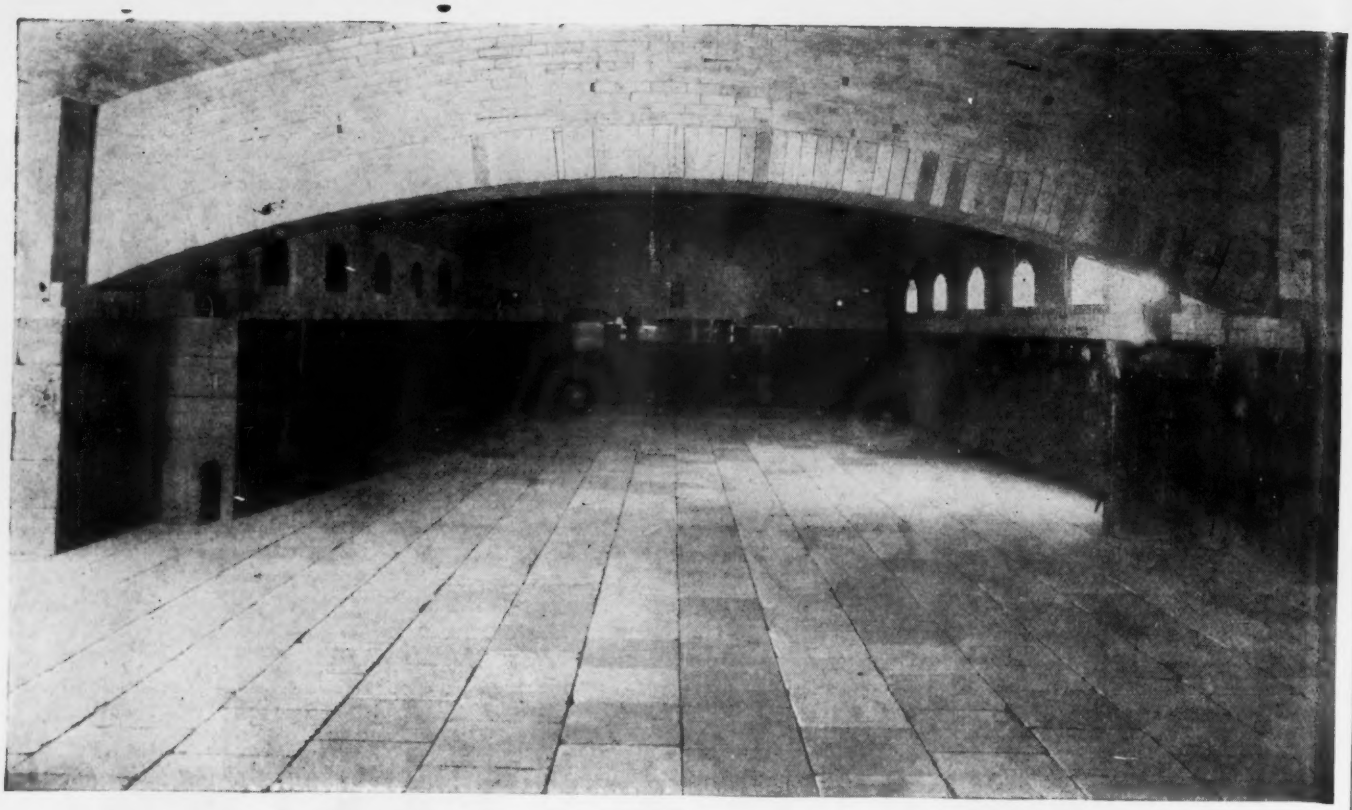

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Ceramic Abstracts Section

Compiled by

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Vol. 23 December 15, 1944 No. 12

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BY RESEARCH

Industries Improve Products; Lessen Production Costs; Decrease Manual Labor; Increase Employment at Larger Wage; Assure Prosperity and Security.

Promotion of Research and Education By Members of The American Ceramic Society Is Profit Making

SUBJECT INDEX TO CERAMIC ABSTRACTS

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Annual Meeting—Reconversion Congress
American Ceramic Society
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PATENTS VESTED IN THE ALIEN PROPERTY CUSTODIAN

The following patents are listed in "Abstracts of Chemical Patents Vested in the Alien Property Custodian, Section 11, Ceramic Materials and Silicates." These abstracts were prepared by the Chicago Section of the American Chemical Society, classified and indexed by the Science-Technology Group of the Special Libraries Association, and edited and published by the Office of Alien Property Custodian. Sections may be obtained from the Office of Alien Property Custodian, Field Bldg., Chicago 3, Ill. The price is $1.00 per section or $25 for the complete set (33 sections).

Section 11 comprises approximately 225 patent abstracts. The patents abstracted below have not previously appeared in *Ceramic Abstracts*.

CEMENTS

Process for the manufacture of aluminous cements. LOUIS GABRIEL PATROUILLEAU (Societe Alumine et Derives). U. S. 1,694,338, Dec. 4, 1928.—Aluminous cements are made by heating a mixture of bauxite or aluminous earths, lime or limestone, and S or S compounds capable of releasing SO_2, e.g., SO_2, SO_3, H_2S, and metal sulfides, sulfates, or sulfites capable of decomposing under heat. Example: limestone 1200 kg., bauxite (60% alumina) 1000 kg., S 44 kg. Advantage: Prevents formation of a vitreous silicate slag; a homogeneous calcium oxysilicoaluminate is formed capable of hardening rapidly and of high resistance.

Cement. CELSO PIETRO BACCOVICH. U. S. 1,696,899, Jan. 1, 1929.—A new hydraulic cement is obtained by mixing intimately a slow-setting Portland cement with 20 to 50% of a very finely pulverized quartz rock, e.g., porphyries, syenites, granulites, granites, or pegmatites. The Portland cement should be one in which the ratio of silicon to alumina is 7:2. The rock is predried at 200° to 500° to increase the fineness obtained by grinding in special superpulverizing apparatus (3 times finer than the Portland cement). The cement obtained has great hardness, density, and strength. It is waterproof, resists marine corrosion, and has great adhesive power and a vitreous finish.

Process of making fused cement. BRUNO BRUHN (G. Polysius). U. S. 1,741,973, Dec. 31, 1929.—Cement can be produced more quickly and economically by feeding the raw materials directly to a rotary kiln and heating to the fusing point of the mixture. The fusing makes it possible to omit the usual fine grinding and mixing before calcining; the raw materials are used as they come from the quarry, in amounts to produce a cement containing 38 to 40% alumina and about 40% lime, the remainder being iron and silica.

Process of manufacturing colored Portland cement. GUSTAV BERGEN, FELIX ENGELHARDT, AND RICHARD STECKHAN. U. S. 1,829,082, Oct. 27, 1931.—Incorporating with ground limestone and clay a flux of phosphates, borates, or halides and adding an oxide of Cr, Ni, Co, or Cu to react with the flux to form coloring compounds, then burning the mixture to form clinker. Example: 100 kg. of ground raw material is mixed with 4 kg. fluorspar, 1 kg. borax, and 0.5 kg. chromium oxide and burned at a sintering temperature in a furnace. The clinker thus obtained is ground and further treated for manufacturing cement. Advantage: A pure green color, not mechanically admixed with the cement but combined therewith into a uniform and stable product; weatherproof colored Portland cement at low cost.

Process for the manufacture of cement. VEUVE GEORGES LEPINE, nee MARIE-THERESE JOSEPHINE ROUSSEL. U. S. 1,868, 240, July 19, 1932.—Cement is made at low temperature by burning lime and clay in a slightly reducing aqueous and alkaline medium obtained by the introduction of H_2, CO_2, or water gas into the kiln together with a Na or K salt and steam. The reducing aqueous and alkaline medium can be obtained in one step by passing ammonia into the kiln and activated by a metal catalyst; reduced iron is used advantageously with NH_3. The clinker is tempered in the same medium in which it was produced. Metals such as Co and Ni facilitate the tempering process; Ni can be incorporated in the clinker by adding Ni oxalate, about 1% by weight. If the clinker must be annealed (in case of unsuccessful tempering), it is reheated in the same medium, either 2 to 3 hr. at 100°C. or a few minutes at 700°C. Example: 500 kg. of dried and ground clay is put into the kiln, a current of NH_3 gas is passed in at about 1000°C., and the charge is kept in the kiln for 10 min. and then suddenly cooled in an atm. of NH_3. Advantages: Low production cost because of the lowered burning temperature; friable clinker which is easily crushed.

Process of rendering cement, mortar, and concrete watertight. WALTER KIRCHNER (Chemische Fabrik Grunau Landshoff & Meyer A.-G.). U. S. 1,844,663, Feb. 9, 1932.—Hydrates of sodium or potassium aluminates or mixtures of such will waterproof cement when used in the proportion of 1.5 kg. of the dissolved substance to 100 of Portland cement.

Method of manufacturing a magnesia cement. RYOSAKU MATSUURA (Minami Manshu Tetsudo Kabushiki Kaisha). U. S. 1,946,327, Feb. 6, 1934.—A magnesia cement consisting of magnesium oxide, magnesium sulfite, and various aggregates and fillers is inexpensive, possesses high strength, hardens quickly, weathers well, and does not crack or shrink. Light burned magnesite is employed for the preparation of the magnesium oxide and the magnesium sulfite. Example: A mixture of 100 parts light-burned magnesite, 50 to 150 parts magnesium sulfite, and 200 to 300 parts finely powdered silica is mixed with water. After setting for a few hours, a cement results that possesses a beautiful finish, has high quality and strength, and is surpassed only by marble.

ENAMEL

Opaquing agents mainly comprising zirconia and process for preparing same. MAXIME PAQUET AND JACQUES OURISSON. APC 275,566 (Serial No.), filed May 24, 1939.—Making opacifiers for vitreous enamels by calcining ground natural zircon in the presence of fluxes such as KNO_3, Na_2CO_3, K_2SO_4, or cryolite at 850° to 1300°C. for 2 to 48 hr. with MgO, Al_2O_3, or K_2O to form a substantially colorless amorphous vitreous substance. Example: Mix 1 kg. zircon, 275 gm. Al_2O_3, 150 gm. cryolite, and 150 gm. Na_2CO_3 intimately and calcine for 16 hr. at 900°C.

Manufacture of enamels. MAXIME PAQUET. APC 335,627 (Serial No.), filed May 16, 1940.—The advantage in using Ce oxide in the manufacture of very opaque enamels is that much less opacifier can be used and the enamel possesses a high covering power and remarkable brilliance; it is nonporous and nontoxic (Sb-free), has high resistance to friction, can be applied in very thin layers, and has high thermal shock resistance. A feldspar frit containing nearly 10% Na fluosilicate and nearly 4% zircon is disclosed. The grinding of the frit with Ce oxide (alone or with other opacifiers) is then carried out. If Ce oxide is used alone, 4 to 7% of the total enamel is used.

GLASS

Ultraviolet-transmitting glass and process of making the same. BERNARD LONG (Soc. Anon. des Manufactures des Glaces & Produits Chimiques de St. Gobain, Chauny & Cirey). U. S. 1,779,176, Oct. 21, 1930.—A light-stable ultraviolet-transmitting glass is made by melting glass,

preferably having a low Fe content and containing 0.05 to 0.5% MnO_2, under reducing conditions by regulating furnace operation or by adding carbonaceous material to the melt. The resulting glass must contain less than 0.02% ferric iron and must be formed with minimum exposure to oxidizing conditions.

Process for preventing the weathering (especially clouding, tarnishing, and lustering) of the surface of glass. KIYOSHI KAMITA (Asahi Glass Co., Ltd.). U. S. 1,782,169, Nov. 18, 1930.—Preventing weathering or clouding of glass surfaces by exposing the glass at about 300° to 600°C. to an acid gas such as SO_2, H_2S, or HCl to combine with the alkalis in the surface of the glass. Example: A mixture of air containing 3 to 5% SO_2 is caused to act upon sheet glass at 300° to 600°C. for 30 min. The white powder formed is removed with a moist cloth.

REFRACTORIES

Fire- and acid-proof plastic substance. AUGUST WOLFSHOLZ (Stettiner Chamotte-Fabrik A.-G. vorm. Didier). U. S. 1,828,211, Oct. 20, 1931.—Fireproof articles may be produced from a highly refractory substance such as ZrO_2 and a binding agent obtained by dissolving a salt in the corresponding acid, e.g., $CaSO_4$ in H_2SO_4. Example: ZrO_2 is triturated and mixed with a binding agent made up of 100 parts 50% H_3PO_4 and 60 parts $AlPO_4$. The mix is molded into shapes, dried, and fired at 800° to 1000°C. A zirconate is produced which is highly refractory and free from pores. Such material may be used as a mortar or as a facing or coating for firebrick, retorts, etc. They dry quickly and possess great adhesive power with low thermal and electrical conductivity.

Manufactures from dolomitic materials. GEORGE DE BECZE. U. S. 2,209,444, July 30, 1940.—Voluminous products are manufactured from dolomite or other raw materials containing calcium or magnesium carbonates. Example: 100 kg. burned dolomite is slaked with water and diluted to 2000 liters. Carbonic acid is introduced into the aqueous suspension containing 5% oxide at 90°C. When the suspension becomes neutral to phenolphthalein, the supply of carbonic acid is stopped. The carbonates thus formed are separated from the liquid after standing and are then dried and pulverized. There is obtained 180 kg. of a light carbonate mixture, 1 liter of which weighs 145 gm.

ROSTER OF THE AMERICAN CERAMIC SOCIETY

★ ★ ★ ★ ★

KEEP YOUR ADDRESS RIGHT

The Roster of The American Ceramic Society, which was published in the October issue, contains about 3200 names. These names and addresses have been checked with all available sources of information. Every member received a return postal card. Advices of the Post Office Department were checked. Yet we are sure that someone was improperly listed.

The Roster is an important document. Whenever anyone in the ceramic industry wants an address, he turns to the Roster. We can make it only as good as the material which you furnish us, that is, your home or business address.

Please check your listing at once. If it is not correct, send us the information. We will see that the change is published.

THE AMERICAN CERAMIC SOCIETY, INC.

2525 N. High St. **Columbus 2, Ohio**

SCHEDULED MEETINGS—PAST AND PRESENT
NOVEMBER, DECEMBER, AND JANUARY

In addition to the Autumn Division meetings, St. Louis Section October 5, Northern Ohio Section October 10, Southern California Section October 25, and Upstate New York Section October 27, the following are the late Autumn and Winter meeting schedules:

Central District Enamelers' Club	Chicago, Ill.	November 4
St. Louis Section	St. Louis, Mo.	November 8
Baltimore-Washington Section	Baltimore, Md.	November 11
Chicago Section	Chicago, Ill.	November 13
Glass Conference	Urbana, Ill.	November 16–17
Canadian Ceramic Society	Toronto, Ont.	November 27
Northwestern Ohio Section	Toledo, Ohio	November 30
Northern Ohio Section	Cleveland, Ohio	December 5
Structural Clay Products Division	Raleigh, N. C.	December 6
Finance Committee	Columbus, Ohio	December 7
Board of Trustees	Columbus, Ohio	December 8
Central Ohio Section	Columbus, Ohio	December 8
Upstate New York Section	Rochester, N. Y.	December 8
Pittsburgh Section	Pittsburgh, Pa.	December 12
New Jersey Ceramic Association	New Brunswick, N. J.	December 15
Northern California Section	San Francisco, Calif.	December 19
Southern California Section	Los Angeles, Calif.	December 22
Pacific-Northwest Section	Seattle, Wash.	December 28
Pittsburgh Section	Pittsburgh, Pa.	January 9
St. Louis Section	St. Louis, Mo.	January 10
Upstate New York Section	Niagara Falls, N. Y.	January 26

47th Annual Meeting	Buffalo, N. Y.	April 15–19

CERAMIC ABSTRACTS

Compiled by

The American Ceramic Society

Volume 23, 1944

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THE BULLETIN SECTION

Volume 23 December 15, 1944 **Number 12**

MARY ELIZABETH COOK

MARY ELIZABETH COOK, SCULPTOR AND POTTER

Our Own WAC in World War I

On her own for five decades, May Cook has achieved success. In museums and in Army medical circles, as well as in tablets, fountains, and decorative tile in many public and private buildings, are enduring records of her fine artistic concepts and her ability to execute them in her own studio. No finer monuments are there of one's abilities than those which Miss Cook has wrought.

May Cook has been generous of her talents, time, and money. She has been without thought of herself. She has not been paid adequately for her services nor for her productions. Without insisting on a service commission in the Medical Corps during the World War of 1914 and without thought of compensation, she not only gave her services unstintingly but paid a large part of the expenses involved. Her interest in the "boys" continued several years. Many of the wounded soldiers worked in her studio without cost either to them or to Uncle Sam. Her work of reconstruction of faces and models for bone and skin grafts brought high praise from surgeons here and abroad—but no financial compensation.

Mary Elizabeth Cook was born in Chillicothe, Ohio, January 1, 1863. Her parents were William Alexander Cook and Anna Sappington Cook. Both parents were of the Virginia aristocracy. Mr. Cook was a financier. He organized and for many years was president of a bank in Chillicothe. With a farm where riding and carriage horses were raised, and with a sumptuous town home, May was brought up in luxury and culture.

Always an individualist, May followed her passion for animals, music, art, and literature. When not racing her horses she spent her leisure hours perched in a favorite tree reading poems, prose, history, and art. In this tree, she would sketch, color, or paint in oil. Often she would make models of things and of persons in whom she was interested. In this happy freedom from dictation and want, her talents and her practical, inquisitive mind developed in an unusual and individualistic fashion to a fruition that became May Cook, an artist with unbounded love and sympathies for her fellows and for nature. Although never robust, she devoted many hours without surcease to acquaintances, friends, and especially to the afflicted. Her services during and following World War I were typical of the services she rendered to all peoples with whom she came in contact. The following word sketch of May Cook's life and works, which appeared in the June 24, 1943, issue of the *Columbus [Ohio] Citizen*, was well merited. We quote it in full.

Wants to Serve Country

"As she lies in bed at St. Anthony's Hospital, recovering from a painful hip injury suffered last January, Miss May Elizabeth Cook, noted sculptor, bright-eyed and vivacious at 79, is hoping for another opportunity to serve her country.

Sculptored Famous Things

"Her bas-reliefs of Presidents James A. Garfield and Rutherford B. Hayes have been exhibited in great salons. Other works have received international recognition.

"But Miss Cook's thoughts, as total war goes on unabated over the world, go back 25 years—back to Ft. McHenry, Md., where her great skill was brought into play to help restore the faces of badly injured soldiers.

Fireplace in Washington, D. C. White and blue glaze and relief in gold luster.

Among First WACS

"'I was among the first WACS'," said Miss Cook, facetiously, as she told of how her services were enlisted by the expert American facial surgeons on her return from France, where she had studied.

"Miss Cook took one look at the 500 men, their faces almost hopelessly disfigured, their minds despairing, at Ft. McHenry, and she was so touched that she then and there prayed God to give her the strength and the intelligence to be of assistance to them.

"'I was furious, too,' said Miss Cook, 'furious because I couldn't do more. I didn't know exactly what to do and the doctors with whom I conferred said they couldn't advise me.'

"Miss Cook evolved a plan and went to work. First she made a drawing of the face as it was, then made another as it should be, getting her ideas from what facial contour remained.

Made Face Masks

"Then she would make a mask. First she would place a thin coat of melted cocoa butter and gauze in the wound so that it would not be irritated. Then she built her mask out of plaster.

"The mask done, she would pour wax into it. This would reveal the size of the wound. Then she would make another cast to show the size of skin to be grafted from his body.

"After the skin was grafted there came the difficult operation of making a model of the bones to be replaced. The bone to be grafted would come from the soldier's ribs.

"One of the men to receive the benefit of Miss Cook's skillful face sculpturing today is president of the Senate in a western state. His face was shattered by a hand grenade in France. His chin, his nose, his mouth, and one eye were smashed.

Had 32 Operations

"They feared for his life. But he stoically bore 32 operations, and when they were all through he was almost as good as new. A couple of years ago he and his wife came to Miss Cook's studio at 1550 Clifton Avenue to see her. You can bet that man thinks Miss Cook is the greatest woman in the world.

"It was infuriating to Miss Cook that so many folks who came to the hospital referred to the soldiers, hurt on the battlefield, as 'the men with funny faces.' She personally chastised some of these cruel persons.

"But Miss Cook was more than a face sculptor. She was a student of psychology. She knew that after the skin was grafted the next problem was to get the soldiers to start moving their facial muscles.

Got Six Pianos

"She got the Red Cross to give her six pianos, one for each ward. She would sing and play. It would be some rollicking song. The boys with battered faces would forget themselves and croak a few notes. Thus began the needed facial exercise.

"Miss Cook doesn't know whether much of this work is going on now, but she is confident that from her World War experience of taking care of 2000 cases she today could be an instructor for others wanting to follow in her footsteps.

"Miss Cook was forty-six years old before she went to school at Ohio State to take ceramic engineering in 1910. Then, in 1912, she went to Paris to learn sculpturing from the famous Paul Wayland Bartlett. After one year of teaching, she was credited with a remarkable achievement —the display of one of her works in a Paris spring salon. Even Ambassador Myron T. Herrick, who was her good friend, went to see it.

Work Displayed in Columbus

"In the State Office Building, you will see Miss Cook's bas-reliefs of Presidents Garfield, Hayes, and Harding, among others. The bronze Pan at the Public Library also is her work.

"But it's war time, and Miss Cook, lying in her hospital bed, smiles bravely and hopes the Government will call her."

(1944)

May is still in her hospital bed.

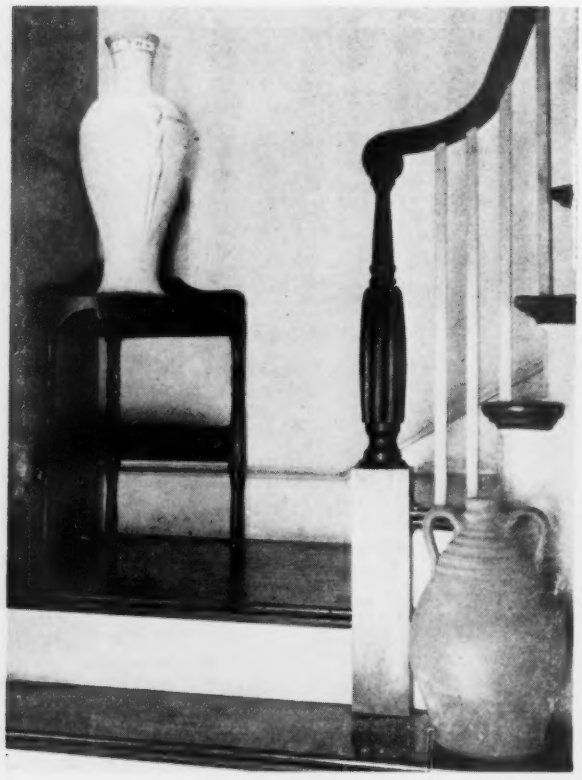
The following is a cryptic statement of her most noted activities and works:

Studied: (1) Ohio State University, Ceramic Engineering; (2) Sculpture in Paris with Paul Wayland Bartlett; (3) Criticisms in own studio and student at Académie Collarossi, Paris; (4) Anatomy at l'École des Beaux Arts, Paris; (5) Sketching at l'École Moderne and Lectures.

Memorial fountain given by Charles Munson. Erected in the Columbus Public Library plaza, Columbus, Ohio.

"Rest." Model of a première ballet dancer in the opera "Comique."

Member: (1) Société Internationale des Beaux-Arts et des Lettres, Paris; (2) National Sculpture Society, New York; (3) National Arts Club; (4) The American Museum of Natural History, New York; (5) American Federation of Arts, Washington, D. C.; (6) Symphony Club of Ohio; (7) American Ceramic Society; (8) National Pen Women of America.



Landing on her studio stairs showing vases made and newel post and rail carved by Miss Cook.

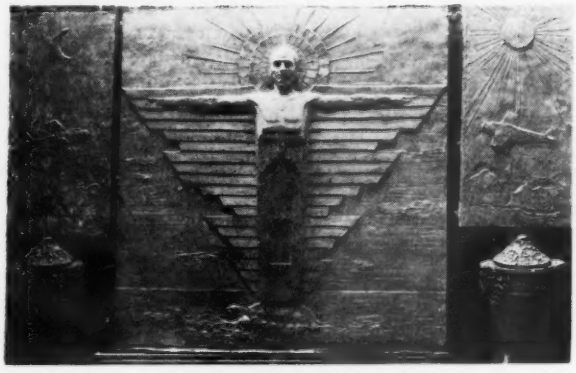
Exhibited: (1) International Peintures et Sculpteurs Exhibit, Paris; (2) Spring Salon, Paris; (3) National Sculpture Society, New York, N. Y.; (4) Ferargil Galleries (one-man show), New York, N. Y.; (5) Grand Central Galleries, New York, N. Y.; (6) National Arts Club, New York, N. Y.; (7) Pennsylvania Academy, Philadelphia, Pa.; (8) Plastic Club, Philadelphia; (9) Art Alliance, Philadelphia; (10) Corcoran Gallery, Washington, D. C.; (11) Toledo Museum (one-man show), Toledo, Ohio; (12) Cleveland Museum, Cleveland, Ohio; (13) Gallery of Fine Arts, Columbus, Ohio; (14) Chicago Art Institute, Chicago, Ill.; (15) World's Fair (sculpture exhibition), San Francisco, Calif.; (16) World's Fair, San Diego, Calif.

Represented: (1) Bronze garden statue (life-size), New York, N. Y.; (2) two marble portraits, New York, N. Y.; (3) architectural terra cotta, Manchester, Vt.; (4) architectural terra cotta, Phoenix, Ariz.; (5) architectural terra cotta (memorial), Colorado Springs, Colo.; (6) Mr. Galbreath, Ohio State Museum (memorial bronze), Columbus, Ohio; (7) Dr. Starling Loving, Ohio State University memorial, Columbus, Ohio; (8) Mack Hall, Ohio State University, marble drinking fountain; (9) Gothic arch of glazed and lustered tile (15 by 8½ feet), Washington, D. C.; (10) garden statue, Kasota stone, St. Augustine, Fla.; (11) memorial fountain, bronze and marble, in plaza of Public Library, Grant Avenue, Columbus, Ohio; (12) memorial in bronze, Mr. Joseph Andrew Jeffrey (7½ by 5½ feet), Jeffrey Mfg. Co., Columbus, Ohio; (13) portrait in marble, Mr. Jeffrey, Bexley, Columbus, Ohio; (14) Metropolitan Museum, photographs and slides, New York, N. Y.; (15) bronze fountain figure in pool, Bexley, Columbus, Ohio; (16) bronze figure in garden, Bexley, Columbus, Ohio; (17) bronze fountain figure in pool, Upper Arlington, Columbus, Ohio; (18) Medical Museum, Washington, D. C. (war work: water colors, drawings, pencil sketch from life (afterwards outlined in ink for Museum

Fountain in bronze in yard of Emile Watson residence, Upper Arlington, Columbus, Ohio.

Record), wax and plaster life-size models showing method of reconstruction of 500 facial cases of the World War; also classified records of the cases; models for bone and skin grafts made for facial surgeons, etc.); (19) memorial in Caen stone (bas-relief) in Broad Street Presbyterian Church, Columbus, Ohio; (20) memorial in bronze of founder of Tuberculosis Society; (21) Children's Hospital: memorial of founder in marble, fountain figure in marble

with pool in terra cotta, two bambinos (terra cotta), and two marble seats, Columbus, Ohio; (22) memorial portraits in bronze of Amelia and Julius Marks in the new Memorial Wing of Columbus Children's Hospital; (23) memorial portrait in bronze of Dr. Schonthal, Columbus synagogue; (24) memorial portrait in bronze of Mr. John McCune, 33d degree, Masonic Temple, Columbus, Ohio; (25) bronze portraits in State Office Building of Chief Justice Swayne, Chief Justice Waite, Chief Justice Wood, President Hayes, President Garfield, President Harding; (26) the "Four Seasons" in terra cotta (half life size) and "Pan" (life size) in garden of Mrs. Walter Martin, Mountain Lake Park, Florida.

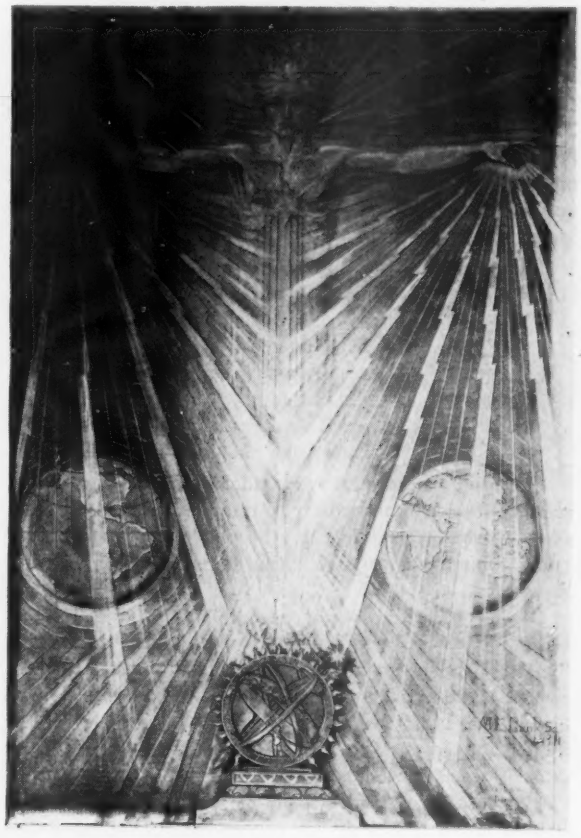


"Creative Thought of Airplane Era." The Chinese tradition that a turtle drank up the flood.

(1944)

MAY COOK TAUGHT AND LECTURED

For two years May Cook gave lecture courses, illustrated with slides and sketches, in the History of Art at St. Mary of the Springs College, Columbus. She gave lectures and demonstrations before several art clubs in various cities of the United States. She gave thirty broadcasts for the Symphony Club of Ohio, many especially to children. She wrote many articles for *The American Magazine of Art*. May was a teacher and a scholar.



Miss Cook's conception of radar. Eleven feet high and six feet wide.

MAY'S REPORT TO THE SURGEON GENERAL

The following are excerpts from the formal report rendered by Miss Cook.

From: May Elizabeth Cook, Re-Aide Medical Department, U.S.A.

To: The Surgeon General

Subject: Report of work from October 18, 1918, to June 7, 1921.

(1) October 18, 1918, reported for duty at Evergreen, where I assisted Mrs. Mayhew Wainwright at Red Cross House.

(2) January 21, 1919, reported for duty at Ft. McHenry to Col. Blair, Maxillofacial Department, and began work which continued with Lt. Col. Schaffer at Ft. McHenry and Columbus Barracks, Ohio: the making of life masks before and after operations (in some cases masks to show

intermediate steps in operation); working models for surgeon of face as it should be reconstructed; models for shaping of cartilage for nose; orbital; or jaw bones; and models for silver plate to hold cartilage in place; pencil sketches from life on which to outline flaps (from which pen-and-ink sketches were made by my assistant, Mrs. H. E. Richardson) for medical record; water-color drawings to secure color for wax casts from life masks of the following patients designated by serial numbers.

(3) Classification as follows: (4) orbital cases 9, (5) nose and eye cases 18, (6) depressed and deforming scars 18, (7) chin cases 4, (8) lip cases 9, (9) deformity from fracture 8, and (10) miscellaneous 30.

Modeling and painting for Departments other than the Maxillofacial at Ft. McHenry: models for silver plates to replace bone in brain operation 2; models for trepanning operations 27, water-color drawings (eye cases) 14, models and casts (for eye cases) 10, and models for dental appliances 12.

Total number of models, molds, and casts made	1345
" " " life masks	198
" " " models, molds, and casts (for bone grafts)	199
" " " plaster casts	189
" " " wax casts	576
" " " pencil sketches from life	147
" " " water-color sketches from life	36

The final report of the Maxillofacial record would be incomplete without a tribute to the intelligent cooperation of the patients in making it; their high courage and fortitude through almost three years of intense suffering and discomfort.

Special mention should be made of Harry Horton, Samuel Fambro, Leon Hanson, Robert Jackson, Lawrence Walzer, Ernest Schell, Erwin Falor, and John Hunt, whose fine attitude in keeping up the morale of the whole group and whose assistance (invaluable) in making the heavier molds and casts cannot be too highly commended and gratefully acknowledged.

The vocational work accomplished by the patients referred to, with that of several others, has been equal to that of students in special schools for modeling and ceramics; my studio being equipped for all sculptural work in marble, plaster, and making and firing of terra cotta, it has been possible for the patients to carry through to completion work of their own designing (lamps, bowls, tea sets, ash trays, and small figures). Horton developed undoubted talent as a sculptor; Fambro as a skilled worker with the potter's wheel and making of tile.

Both at Ft. McHenry and Columbus Barracks, the claywork has proved to be (to officers and privates) of unfailing and absorbing interest to the nervous, restless patient, and I strongly commend it as a vocational work of the highest therapeutic value; also affording an opportunity to supply the much-needed skilled clayworker for our clay industries and to develop our natural resources in clay, which have scarcely been touched.

The making of the casts from the life masks has afforded a study of much interest of the types of our fighting men—representing all phases of our national life and from which an ethnological record of much historic value might be made.

LIFE MASKS. These were made over wounded faces before surgeons had touched them as follows: The wound was filled carefully with gauze which I dipped in melted cocoa butter; covered this by red gum modeled in warm water to thinnest possible sheet; vaseline painted round edges. Then mixed plaster of Paris quickly and painted it over the face.

After making one or two, I could prepare face, mix plaster, and lift it from face in about 25 minutes or less. In this life mask pressed clay, thus securing model of face in clay. Next morning patient would pose for me and would remove clay to exact size and depth of wound; model exact size and shape of bone missing (for shaping and size of bone graft); in a gelatin-glue compound (formula for which was given me by a French surgeon) would cast exact size for skin graft required to cover hole in face.

This gelatin-glue compound had same elasticity as skin; also would tint it when melted exact color of patient's skin. Over clay model pressed in life mask made a plaster mask in which to cast wax model for record now in Medical Museum; after which would remodel clay as face should be completely reconstructed; then made plaster cast over this, in which cast plaster model showing face as it should be reconstructed for surgeon's study. For every life mask listed, five models and masks were made.

MAY COOK, A MUSICIAN

Casual acquaintances have not realized that May Cook was a versatile and accomplished musician. Before her teen ages May had had piano lessons, and so apt was she that in her pigtail years she could play the piano for social sings at home, in school, and in church. The family physician enjoyed playing the violin and often the doctor and the ten-year-old May played duets. The inquisitive, ambitious May soon learned to play the violin. One of her colored house servants strummed the mandolin and banjo and taught May to play them. Often the colored servants would sing while May played.

Among the 500 maxillofacial cases was a Polish boy named Stanley. Stanley had had both eyes shot out and his suffering was intense. May tried to comfort him. She learned that he had played a violin in an orchestra, so she secured a violin and played for him. He could not talk but he stopped his agonizing groans when she played. He reached for the violin and braced against the pillow he began to play.

Often on Sundays at Fort McHenry, May would lead the boys in singing hymns. Often she had the colored boys singing spirituals with banjo or mandolin accompaniment as she had sung them with her "Aunt Jane," her mother's colored cook. "Ham Bone" was a favorite, and often the boys asked her to sing that song as well as other plantation songs.

It was hard not to sing and soldiers caught the rhythm quickly, and before they realized they were singing with her, using their jaws and facial muscles freely. Thus was their morale built and control of their facial muscles obtained.

May Cook's versatile musical talents immensely added to her artistic talents in salvaging the boys of World War I who had been sent to Fort McHenry because of facial injuries.

SYMPOSIUM ON "SIGNIFICANCE OF TESTS ON REFRACTORIES"

The following three papers were part of the Symposium which was presented at the Forty-Sixth Annual Meeting of The American Ceramic Society, Inc., Pittsburgh, Pa., April 4, 1944. Clyde L. Thompson, chairman of the Refractories Division, acted as chairman of the Symposium. E. E. Callinan was chairman of the Program Committee.

See Bull. Amer. Ceram. Soc., **23** [9] *310–20 (1944) for papers by S. M. Phelps, F. A. Harvey, and W. S. Debenham, also Bull. Amer. Ceram. Soc.* **23** [10] *367–73 for papers by R. B. Sosman, E. R. Hannah, and L. C. Hewitt.*

SIGNIFICANCE OF A TESTING PROGRAM FOR GLASS-PLANT REFRACTORIES*

By R. K. Smith

Abstract

The economic significance of testing refractories is emphasized. The two general types of refractory failures (those due to heat alone and those due to heat plus contamination) are considered. Tests applicable to each type are discussed, with particular reference to tests used by the Corning Glass Works Ceramic Laboratory. A sag test and a reheat test which have been found useful in evaluating failures due to heat alone are described, with illustrative data. The factors involved in testing refractories for failure from chemical attack are briefly discussed.

I. Introduction

The primary significance of any industrial program is economic, rooted in a desire to increase profits. The testing can save money in many ways, some of the most prominent of which are as follows:

(1) Confining the worst refractory failures to the laboratory instead of having them occur in plant service. This procedure might be termed the establishment of minimum standards.

(2) Specifying the cheapest of several available refractories which have the required significant physical properties, thus avoiding the expense of paying for non-essential qualities. This might be termed the establishment of maximum standards.

(3) Specifying, in cases where opposed factors are involved, the optimum refractory for the unique combination of properties required. This might be termed the establishment of balanced standards.

The best comprehension of the significance of a testing program can probably be gained through a consideration of the refractory failures which are characteristic of glass-plant service and the tests which attempt to measure the properties involved in these failures. In addition to the appropriate A.S.T.M. test, it might be interesting to mention some other tests which the Corning Glass Works Ceramic Laboratory has developed to assist in the solution of similar problems, as well as some tests which relate to problems not yet approached by the A.S.T.M.

Refractory failures, in general, fall into two classes:

(1) Those due to the effects of heat on the refractory composition itself.

(2) Those due to heat plus the addition of some foreign material associated with the conditions of service.

* Received April 4, 1944; revised copy received August 24, 1944.

II. Refractory Failures from Heat Alone

Any refractory, if heated to a sufficiently elevated temperature, will develop a liquid phase which flows to allow deformation. At a given temperature, the rate of flow is related to the time and pressure. For very low pressures, the temperature of flow is given by comparison with standard pyrometric cones. This is the familiar P.C.E. test so ably discussed by Sosman.[1]

Most refractories, however, must bear a considerable load in service. In recognition of this fact, the A.S.T.M. developed the load test which Kraner[2] has described and discussed. To supplement this test, Corning's Ceramic Laboratory has developed a rate-of-sag test which not only gives a temperature of failure, but also gives data on the rate of failure at various temperatures.

A refractory bar, 1 by 1 by 10 cm., is supported cantilever fashion in an electric furnace with a point on the free end under observation with a filar telescope which can measure its deflection to 0.001 inch, and is heated until it starts to sag. After flow first becomes evident, the heating is interrupted at 50°C. intervals for one-half hour to determine the rate of flow. Heating is then continued to 1600°C. or until the flow becomes too rapid to permit further measurement. (The reference point sags out of sight.) Rate-of-flow data can then be plotted to give graphs such as those shown in Figs. 1 and 2.

In connection with the refractories of Fig. 1, which are a series of glass-pot compositions, it is probably noteworthy that a pot made of refractory 4 failed in the furnace by sagging even before it was filled with glass, whereas pots made of refractory 1 have been in service for four months and longer without appreciable deformation.

[1] R. B. Sosman, "Significance of the Pyrometric Cone Equivalent Test of Refractories and Refractory Raw Materials," *Bull. Amer. Ceram. Soc.*, **23** [10] 367–70 (1944).

[2] H. M. Kraner, "Hot Load Test." Discussion included in this Symposium (not published).

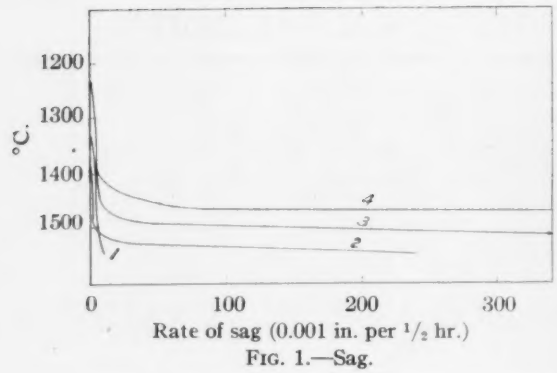


FIG. 1.—Sag.

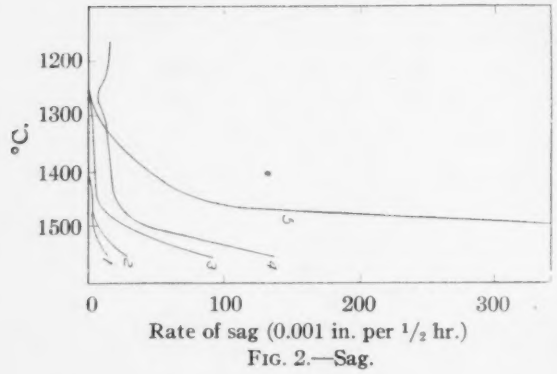


FIG. 2.—Sag.

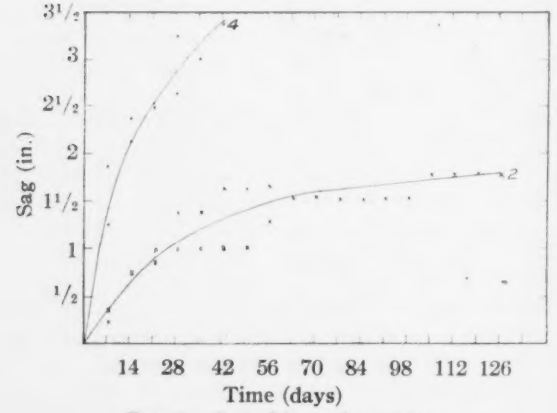


FIG. 3.—Sag of boots in service.

The refractories whose sagging characteristics are shown in Fig. 2 have been used as boots in the refining ends of glass tanks. Figure 3 is a graph of the sag of boots made of refractories 2 and 4 of Fig. 2 in actual service. Although the sag is plotted against time at constant temperature, the results are quite similar to what a study of Fig. 2 would lead one to expect. Boots of refractory 4 sagged so badly in six weeks that they had to be removed from the tank (see Fig. 4), whereas twenty weeks' service did not cause serious sag with boots of refractory 2. Figure 4 includes several photographs of a boot of refractory 4, showing the deformation during service. Each photograph is a composite of two negatives, one of the original boot and one of the boot after use. Figure 5 is a photograph of a boot of refractory 2, after similar service of longer duration. It is readily apparent that the service data confirm the conclusions drawn from laboratory tests. Refractory 5 was measured and included in Fig. 2 as a matter of historical interest, as it was the boot composition in use twenty-five years ago, when lower temperatures were customary.

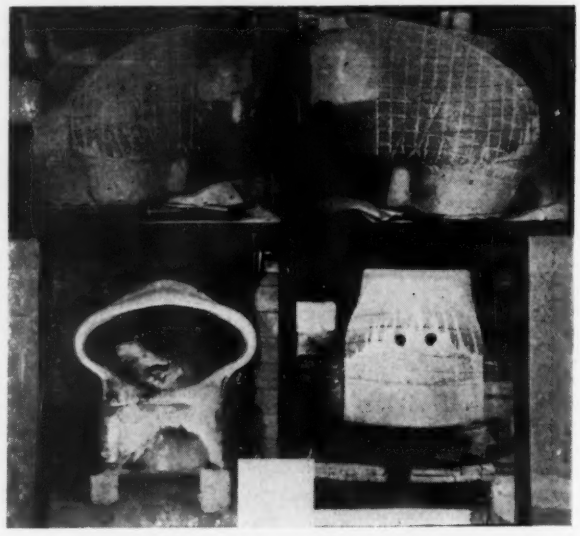


FIG. 4.—Composite photograph of a boot of refractory 4 of Fig. 2 made by printing with a negative of the boot after service superimposed on a negative of the same view of the boot before service. Serious deformation, or sag, during service is shown.

FIG. 5.—Photograph of a boot of refractory 2 of Fig. 2 after more severe service than the boot of Fig. 4, showing no deformation during service.

Another annoying refractory failure is shrinkage at high temperature. The A.S.T.M. has recognized this in its reheat test, described and discussed by Petrie and Walters

(see pp. 464–68, this issue). Additional data on this failure can be obtained by heating a specimen in a manner similar to that just described, but supported on a bed of sand with both ends under observation with filar telescopes which permit determination of its length to 0.002 inch. The type of information resulting from this test is shown in Fig. 6.

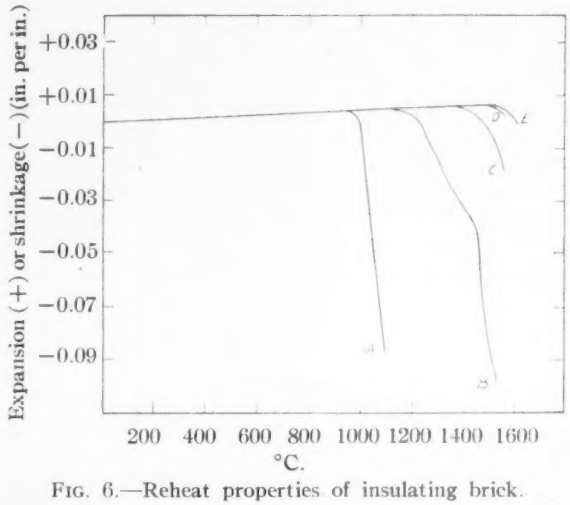


FIG. 6.—Reheat properties of insulating brick.

The photograph in Fig. 7 shows the result of heating the surface of an insulating brick above the safe temperature derived from Fig. 6. Refractory B of Fig. 6 was heated to 1550°C. (safe maximum temperature 1200°C.) to cause the severe surface shrinkage shown by specimen B. Specimen A, which was heated to 1200°C., shows no shrinkage. Each specimen was held at peak temperature for 12 hours.

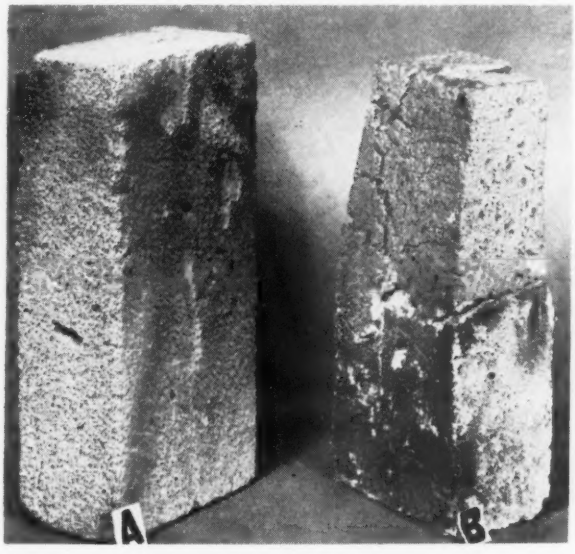


FIG. 7.—Two specimens of refractory B of Fig. 6: (A) after service at 1200°C.; (B) after service at 1550°C.

III. Refractory Failures from Chemical Attack

The glass technologists are the "forgotten men" of the A.S.T.M. in this field of testing, for no standard tests are available. In nearly all cases of interest to the glass industry, the medium which attacks refractories is a liquid.

The study of attack of refractories by liquids will include all the refractories used to retain the glass during the melting process, as this problem is the major concern of a refractory testing program for glass plants. If those refractories which do not produce a glass of satisfactory quality are disregarded, the chief concern becomes one of increasing the life of the refractories, i.e., finding the refractory having the lowest rate of solution in a given glass.

The tests which attempt the measurement of this property are numerous and devious; at least six varieties are used in the Corning Glass Works at the present time. It would be hopeless, as well as useless, to attempt to describe all these tests, so the present discussion will be limited to a statement of some useful guiding principles resulting from testing experience.

(1) Temperature Control

As the rate of attack of molten glass on refractories is directly proportional to the fluidity of the glass, which increases almost logarithmically with temperature, it is extremely important that temperatures be closely controlled. A temperature variation of 25°C. between two tests can obscure the effect of an important difference in chemical composition of the refractories being tested.

(2) Size of Specimen

Specimens varying from millimeter cubes to 12- by 18- by 24-inch tank blocks have been used successfully. The tendency has been toward small, carefully selected specimens, at least for preliminary tests. These specimens must be representative of the portion of the refractory which it is desired to test. Measurement of variability can be attained by the use of sufficient samples for statistical analysis, or alternatively by selection of samples from the weakest and strongest portions of the refractory.

One strong inducement favoring small test specimens is the comparative ease with which the temperature can be accurately controlled in small furnaces.

By exercising proper judgment in their interpretation, tests conducted on small specimens can be made to divulge most of the information usually accumulated through data from larger and more expensive test specimens. One danger point in testing which calls for caution in interpretation of results is the disintegration of the test specimen so as to leave discrete particles of refractory in the glass. A study of the rate of attack should be conducted with reference to solution from the surface of the refractory rather than from a volume, and test specimens should be carefully examined to insure that this condition has been met. When penetration of the refractory by the molten glass is severe enough to allow attack from within, prediction of results is difficult and should be attempted only with great caution.

Successful interpretation of tests also involves a general knowledge of what is to be expected from refractories of various compositions. It is desirable to determine the bulk density of each specimen. When this varies from the normal density for that chemical composition, proper allowance for this variation should be made in predicting service results, and increased caution in observation should be exercised.

(3) Container for Glass

Although some tests use the test specimen, in the shape of a crucible, for the glass container, the tendency in this Laboratory in recent years has been increasingly toward the use of platinum crucibles to contain the glass and the test specimen. Platinum not only avoids numerous problems of contamination and solution, but is actually cheaper in the long run. Some platinum crucibles have been in continuous service for more than five years at temperatures ranging up to 1600°C. The use of a single small refractory test specimen in an individual platinum crucible with a small amount of homogeneous glass also allows the determination of the amount of refractory dissolved by chemical analysis of all the glass. This has sometimes been a useful technique for the accurate study of refractory corrosion.

(4) Glass

To assure glass of uniform quality in testing refractories, the simplest procedure is to use carefully selected, defect-free cullet. This cullet can be ground in a ball mill to pass a 100-mesh screen, to assure homogeneity, and the physical properties checked to assure correctness of composition. Control problems are simplified by grinding a year's supply at one time. Some are sure to criticise the omission of raw batch, but experience has shown that the properties of cullet are satisfactory for nearly all glass contact refractory tests. Repeated tests using all cullet vs. all batch have produced identical results when conditions were carefully duplicated and the batch was melted without serious segregation. The confusing factors in this subject are apparently (1) the cooling effect of raw batch, which tends to reduce amount of corrosion, and (2) segregation of batch, which may increase the amount of corrosion. Notable exceptions to this statement can be found in those glasses which segregate during melting, such as those which form a corrosive layer of fluid salt cake on the surface. In such cases, the specific effect of the segregating material must form the basis of investigation of the attack on refractories.

Corning Glass Works
Corning, New York

SIGNIFICANCE OF NAVY SPALLING TEST*

By Lieutenant W. T. Tredennick, USNR, and J. F. Kelly

Abstract

With the development of the Navy spalling test, thermal spalling in naval boilers has been reduced from a major to a minor cause of failure. The advantages of the test are pointed out and illustrated by showing the results of service trials of brick giving 26, 8, 3.5, and 1% loss in the test.

I. Introduction

Until 1931, a P.C.E. determination, a chemical analysis, and a comparison test were made on the firebrick purchased by the Navy. The comparison test consisted of building two walls as removable sides of a furnace, one of an acceptable brand, the other of the test material. The furnace was run at 2900°F. for 24 hours, was shut down, and air from the high-pressure burner was blown through the furnace for 2 hours. The furnace was fired for another 24 hours at 3000°F., was shut down, and air was then blown through the furnace for 2 more hours. After the furnace cooled, the walls were removed and a visual inspection was made for fusion and softening. The amount of cooling obtained was insufficient to cause spalling to any measurable degree, although the main cause of failure was spalling, which was apparent after very short operating periods, as is shown in Fig. 1.

II. Description and Purpose of the Test

In 1931, the Bureau of Ships authorized the Naval Boiler and Turbine Laboratory to modify and improve the Navy simulative service test. This investigation was carried out between December, 1931, and December, 1932, with three objectives in mind: (1) to measure the resistance of the test material to high temperature, (2) to produce a measurable amount of spalling, and (3) to decrease the time of testing and also reduce the cost. As a result of this work and without trying the water-dip method, although it was given some consideration, a modified A.S.T.M. panel spalling test was started. A measurable amount of spalling was developed, as is shown in Fig. 2. The average spalling loss of brick purchased at that time was approximately 20%. The type of spalling developed was the same as that produced in service. The A.S.T.M. gas furnaces were modified so that oil could be used for fuel. As all are familiar with the A.S.T.M. method of spalling, only those items of the Navy test which differ will be described. Arrangement of the border brick is different, and the fourteen test brick in the panel are insulated by $2^1/_2$ inches of 2500°F-grade of insulating brick and 1 inch of insulating block. The insulating material is not cut in the same manner as the present A.S.T.M. test. After this test was developed, the tentative specification requirement for spalling loss was set at 20%. After a short length of time it was reduced to 15%. The present requirement is 8%; the test brick with this amount of loss is shown in Fig. 3. As shown in Fig. 4, it is possible to have a failure from spalling with brick having an 8% loss in the test.

The first part of the test (called preheating by the A.S.T.M. and refractoriness by the Navy) consists of two continuous high-temperature runs. The furnace, fired by a high-pressure oil burner, is brought up to 3000°F. in 6 hours and is held at that temperature for 24 hours with a furnace pressure of $^1/_2$ inch of water. The temperature is then reduced to 2900°F. and fired for an additional 24 hours. The panel is allowed to cool at the furnace to approximately room temperature and is then removed and

* Received April 11, 1944; revised copy received October 2, 1944.

photographed. The preheating develops vitrification in the brick equivalent to that observed in the same material after three years of moderate operating conditions aboard ship. Brick lacking the required refractoriness to withstand service in naval boilers will fail owing to fusion or shrinkage.

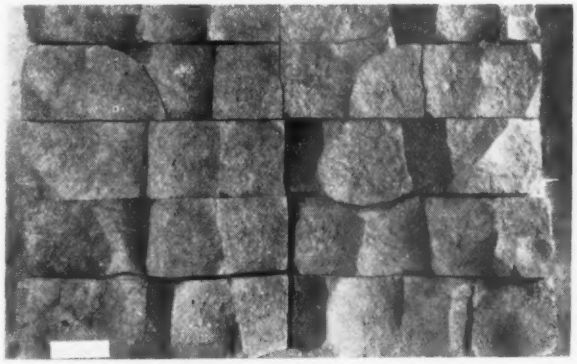


FIG. 1.—Material with 26% loss on approval test. This type of material was used before 1934.

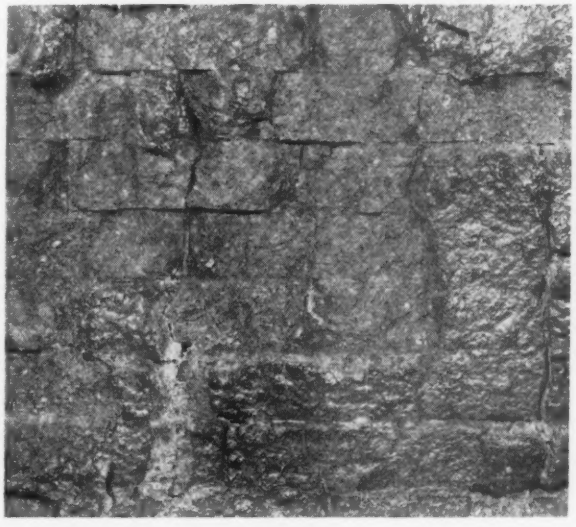


FIG. 2.—Test brick in service after 100 hours of severe operating conditions. This type of failure or worse was general before 1934.

The furnace temperature during this test is automatically controlled and continuously recorded by a radiation pyrometer. In addition, the furnace temperature is measured by an optical pyrometer every 15 minutes. Two optical pyrometers are used, one each hour on the hour and one for the other three readings. A third optical pyrometer is held as a semistandard and is used once each 24 hours as a check on the other two instruments.

The second part of the test is designed to produce thermal spalling. The panel is given 10 cycles of 20 minutes each of alternate heating at 2650°F. and air cooling to approximately 700°F. The panel is cooled, disassembled, and weighed. All pieces which can be removed by thumb pressure are dislodged and the panel is again weighed. The difference in weight from the original weight expressed in per cent is the spalling loss.

TABLE I

Superduty firebrick Class B	No. of tests	Maximum (%)	Minimum (%)	Avg. (%)	Standard deviation*
1	6	2.1	0.4	1.0	0.54
2	6	4.5	0.0	1.0	1.57
3	4	3.1	0.8	2.1	0.89
4	14	1.5	0.2	0.5	0.34
5	11	3.1	0.2	2.2	1.03
6	6	5.4	0.9	3.8	1.65
Superduty plastic No. 1	8	1.3	0.5	0.8	0.24
Superduty plastic No. 2	9	3.8	1.0	2.1	1.00
Superduty plastic No. 3	8	2.7	0.3	1.0	0.87

* See A.S.T.M. Manual for Interpretation of Refractory Test Data, 1934.

The number of heating and cooling cycles required was determined by trial and error, and they varied from 10 to 26. By using 10 cycles, it was possible to develop sufficient spalling and to make a complete test in one day of op-

FIG. 3.—Material with a spalling loss of 8% on the approved test.

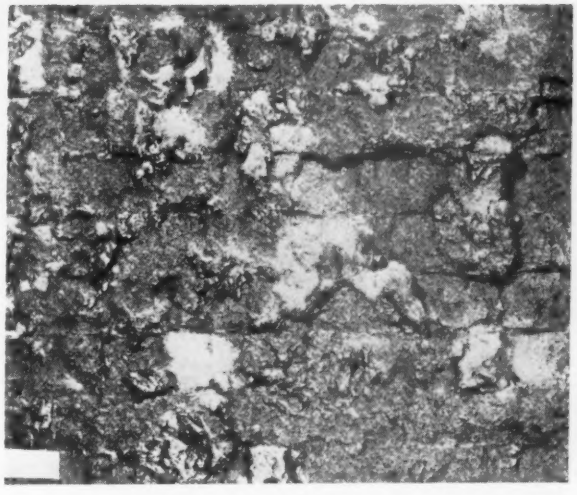


FIG. 4.—The brand of brick of Fig. 3 after 717 steaming hours. They have spalled to a depth of $1^1/_2$ to 2 inches on the major portion of the wall.

eration. A water spray was also tried, but was rejected because sufficient cooling was developed as a result of the large volume of air available. Fifty-eight hundred cubic feet of air per minute was blown against the panel through a 20- by 20-inch duct.

III. Summary of Test Data

Table I lists the results obtained on representative inspection samples during the 6 months prior to March, 1944.

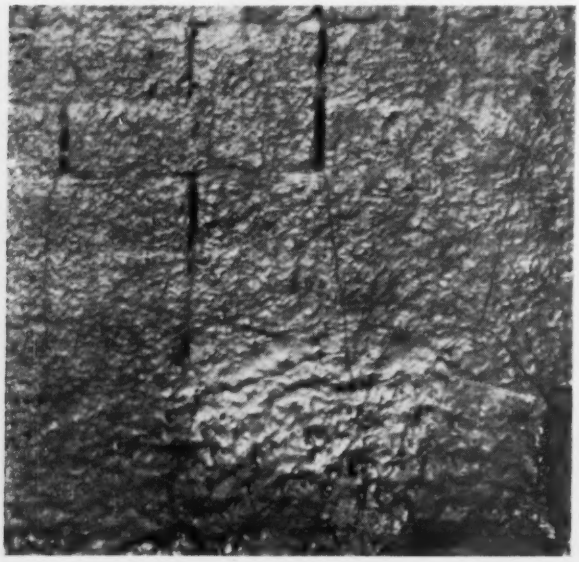


FIG. 5.—Brick with 1% spalling loss on the approval test, after 717 steaming hours, installed in the wall adjacent to the brick in Fig. 4.

TABLE II

Firebrick samples	Spall No. 1 (%)	Spall No. 2 (%)
1	0.9	1.7
2	2.5	3.1
3	22.3	23.6
4	3.5	1.2
5	0.2	0.5
6	2.5	2.8

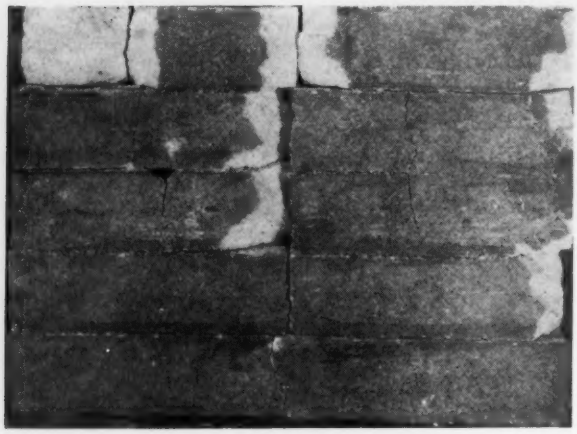


FIG. 6.—Spalling loss of 3.5% on the approval test.

The materials in Table I showing the high results may not be accepted, if they were higher than those obtained on the approval test of that particular brand. Actual average spalling loss of the materials accepted was 1.6%, with a maximum range on the highest results of 4.5%. The percentages listed in Table I are representative of figures that would be obtained on innumerable tests. This is good evidence that the Navy is obtaining and using material with uniform and exceptionally good spalling resistance. Figure 5 is representative of the service results obtained from brick with an average spalling loss of 1.6%. Brick that have 3.5 to 8% loss, as shown in Fig. 6, will develop some thermal spalling in service, as shown in Fig. 7, before failing from other causes. Brick with less than 3% spalling loss in the test fail as a result of slagging or structural changes, as shown in Figs. 8 and 9, rather than from thermal spalling.

IV. Comparison of Identical Samples

Results on any one shipment of material are always comparable. For instance, when an approval sample is tested, it is often possible to make two spalling tests. When sufficient inspection samples arrive, apparently from the same manufactured lot, two tests are made and the spalling losses always compare favorably. Table II gives the results of the check tests.

FIG. 7.—The brand of brick of Fig. 6 after 685 steaming hours. Spalling has developed to a depth of $1\frac{1}{2}$ inches in some portions of the wall.

Sample No. 3, made by one manufacturer, was submitted by two different companies for their approval tests. In addition, two of the tests were made on material submitted for approval and the other three results were obtained from inspection samples. The figures in Table II present good evidence that the test gives consistent and accurate results. When the fact is considered that the person making the test removes the actual spalled portions by thumb pressure, it is rather surprising to have results compare as well as they do. During the past eighteen months, the writers have had an opportunity to see a number of different brands of brick in actual service

TABLE III

Superduty (Class B) approval samples	1936 (%)	1943 (%)
1	10.6	1.7
2	5.5	0.35
3	7.1	3.0
4	3.4	5.1
5	8.1	1.3
6	5.64	0.6
7	4.47	1.2
8	9.00	2.2
Avg	6.7	1.93

tests. In every case where the test results were approximately the same, the service results were found to be comparable also.

V. Improved Spalling Resistance of Brick

To show the improvement accomplished in the resistance of the brick to spalling, Table III gives the spalling results of eight Class B brick that were on the approved list in 1936 compared with the results of the same material in 1943.

VI. Summary

Brick that show 3% spalling or less will stand the most severe naval service and not fail as a result of thermal spalling. Thermal spalling has been reduced from a major cause of failure to the point where it is now one of the minor refractory problems.

U. S. NAVAL BOILER AND TURBINE LABORATORY
U. S. NAVY YARD
PHILADELPHIA 12, PENNSYLVANIA

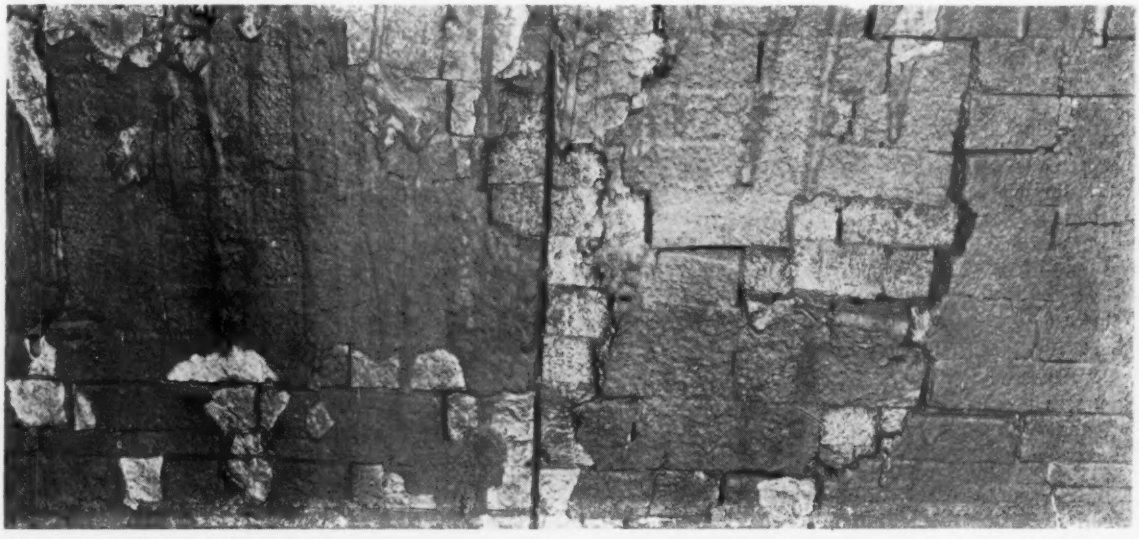


FIG. 8.—Brick which showed 1 1/2% shrinkage in the permanent volume change test as they appeared after 300 hours of service. Large shrinkage cracks have developed in addition to the vertical expansion joint in the center of the wall. The peeling and severe spalling which occurred are the result of a structural change in the brick.

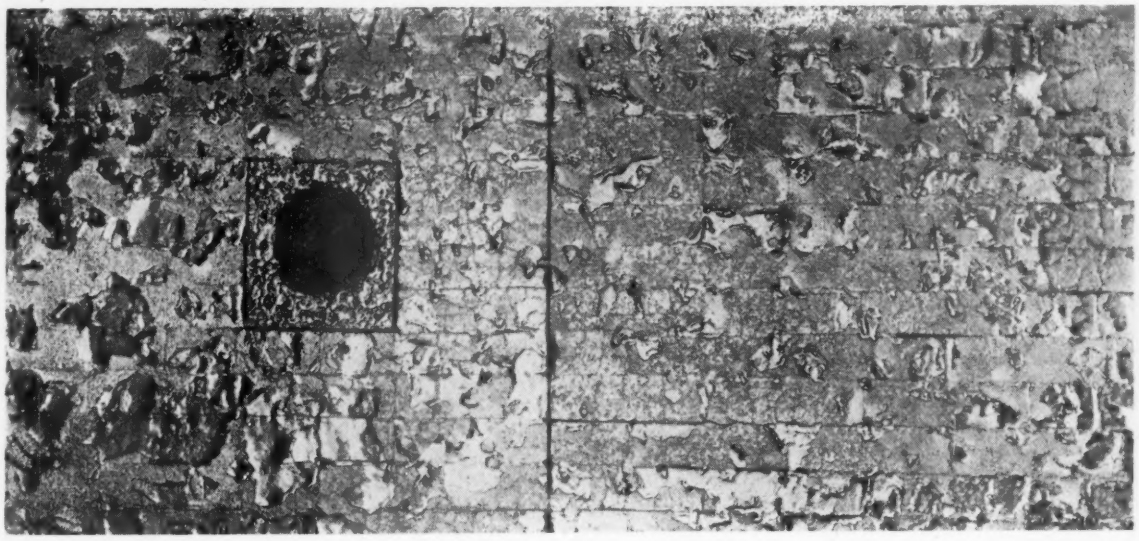


FIG. 9.—Three types of Class B brick, all with a spalling loss of less than 2.5%. The peeling shown is a progressive action, thin sections of an average thickness of 1/16 inch falling from the face of the brick.

REHEAT TESTS ON FIRE-CLAY AND SILICA REFRACTORIES*

By Earl C. Petrie and Charles P. Walters

Abstract

Test data on fire-clay and silica refractories are presented which show the effect of firing temperature and its relation to the changes brought about in the standard A.S.T.M. reheat tests.

I. Introduction

For approximately twenty-five years there have been specifications dealing with permanent linear and volume change after high-temperature reheating of fire-clay brick. In early testing procedure it was the practice to combine this test with the determination of porosity and related properties. Specification C 20–18 T of A.S.T.M. required that volume, porosity, and related properties be determined by immersion in kerosene. A draw trial was conducted on several pieces, starting at 1200°C., with subsequent removal of additional samples at 50°C. increases in furnace temperature. Volume before and after reheating was compared and the reheat change was determined. This test was useful in that it could be used in evaluating unfired clays and refractory mixes as well as fired refractory products.

The A.S.T.M. Standard Definitions for Clay Refractories C 27–20 for High Heat-Duty Clay Firebrick specified that when duplicate samples were heated to 1400°C. for 5 hours they must not show a contraction of more than 1.5% nor an expansion of more than 1% of original length. These standard definitions were later revised to eliminate the provision in respect to expansion.

In the period extending from 1920 to approximately 1933, the reheating test received little attention. In 1934, Committee C–8 of A.S.T.M. proposed Test Procedure C 113, which specified that full 9- by $4^1/_2$- by $2^1/_2$-inch brick be subjected to a temperature of 1400°C. for 5 hours and the change in length determined. Before adopting C 113 as a tentative standard, extensive reheating tests at 1400°C. were conducted. Procedure C 113 became standard in 1936 and since that time has received general approval as a control test as well as a specification test for standard fire-clay brick.

II. Literature Review

A search of the literature reveals few reports that deal with high-temperature reheat tests on refractories. This testing originally was confined to draw trials in contrast to the present standard reheat test which determines linear change at definite temperatures.

Howe[1] reports that the reheating test is sometimes used either to check the results of the load test or to replace them. Usually the results secured may be compared directly, but erroneous conclusions may be drawn when comparison is made between a given mixture of clays formed by hand and one formed by steam pressing. Often the dense machine-made product will expand decidedly during the test, whereas the more open handmade product will not. A P.C.E. of cone $32^1/_2$ indicates that the raw material was very refractory but that the large expansion obtained on the steam-pressed product is a function of density and process of manufacture. This expansion is neither a true measure of refractoriness nor is it an indication of unsuitable raw materials but is the result of the action of other factors.

Ferguson[2] believes that the high-temperature reheat test is the simplest test which can be used in a firebrick plant to maintain the quality of the product. With most clays, iron is a common impurity and any marked increase in its content is quickly noted by spots developed in the test. Samples can be taken from the kiln or cars before the brick are cool and the test can be completed before the brick are shipped.

Booze and Phelps[3] find that reheating brick to 1400°C. for 5 hours is not a satisfactory means of classifying refractories according to quality. When expansion occurs in hard-and soft-burned brick, the soft brick expand much more than those which have been fired hard. At the time the reheating test was developed as a means of classifying brick, it was not recognized that expansion would take place from any other cause than overfiring. It was later developed that expansion occurred when the brick did not show evidence of overfiring. This expansion, known as secondary expansion, is a function of the rate as well as the temperature of original firing. Secondary expansion appears to be greater under reducing than under oxidizing conditions. There is no definite relation between linear change and apparent porosity in the reheating test. In some cases, a marked expansion is accompanied by an increase in porosity, in others by a decrease. The true porosity would probably always increase with expansion, as there seems to be no change in the specific gravity of the material. The rate of heating in the reheating test determines the degree of expansion, a fast rate effecting considerably more expansion than a slow rate.

McDowell[4] reports that the reheating test is one which has been extensively used as a criterion for the quality of fire-clay brick.

* Received June 1, 1944; revised paper received October 19, 1944.

[1] R. M. Howe, "Report of Committee C–8, Appendix: Vital Factors in Testing Fire-Clay Refractories and in Interpretation of Results," *Proc. Amer. Soc. Testing Materials*, **20** [Part I] 278–90 (1920).

[2] (*a*) R. F. Ferguson, "Refractories Question Box," *Bull. Amer. Ceram. Soc.*, **3** [12] 465 (1924).
(*b*) R. F. Ferguson, "Symposium on Control Testing in Clay Firebrick Manufacture: IV, Laboratory Testing of Clays," *ibid.*, **11** [7] 171–72 (1932).

[3] M. C. Booze and S. M. Phelps, "Factors Involved in Spalling of Fire-Clay Refractories with Notes on Load and Reheating Tests and Effect of Grind on Shrinkage," *Jour. Amer. Ceram. Soc.*, **8** [6] 361–82 (1925).

[4] J. S. McDowell, "General View of Testing of Refractories," *Amer. Refrac. Inst. Tech. Bull.*, No. 28, 8 pp. (Oct., 1928); *Ceram. Abs.*, **8** [6] 417 (1929).

Phelps and McDowell[5] divide the tests on refractories into three general types, viz., durability, suitability, and control. The object of the reheat test is to determine the constancy of volume of brick at a temperature higher than that at which they were fired. Studies show that many brick of high refractory value in the reheat test exhibit expansion phenomena similar to overfiring. This renders the interpretation of reheat data difficult, as expansion of brick in the reheat test is not always an indication of inferior quality.

Trostel[6] reports that the reheat test is designed to determine the volume stability of a brick free from superimposed load at a temperature generally higher than that at which it was fired and close to that at which it will be used. The results obtained generally are due to either uncompleted or new mineral reactions at the higher temperature of the test. Consumers who use the test should be careful not to interpret expansion as overfiring due to the development of vesicular structure.

III. Experimental Procedure

Other investigators have shown that the degree of burn of a refractory, in many instances, governs the changes brought about in the standard reheat test. For this reason, tests on high heat-duty brick in the present investigation were confined to brick fired to three different temperatures and, in addition, to three different processes of manufacture, viz., handmade, dry-press, and stiff-mud deaired. The various burns will be designated as resets, medium-hard, and hard burn.

The tests on superduty brick were confined to the dry-press process only and to three different firing temperatures.

A similar procedure was followed for silica brick.

IV. Chemical Analyses and P.C.E.

Typical chemical analyses and P.C.E. of the several types of brick tested are listed in Table I.

TABLE I

CHEMICAL ANALYSES AND P.C.E. OF BRICK TESTED (%)

	Handmade	Dry-press	Stiff-mud	Superduty	Silica
Silica	52.00	50.40	51.45	54.53	95.87
Alumina	40.99	42.02	41.10	40.98	0.96
Iron oxide	2.44	2.32	2.36	1.37	0.47
Titania	2.19	2.62	2.48	2.10	0.10
Lime	0.14	0.17	0.14	Trace	2.15
Magnesia	0.36	0.26	0.28	0.20	0.15
Alkalis	1.78	1.97	2.05	0.81	0.25
P.C.E.	32½–33	32½–33	33	33–34	31–32

V. Discussion of Results

(1) Handmade Brick

The brick samples for this portion of the investigation were made under the usual plant control procedures for quality and were fired in rectangular downdraft kilns. The reset brick were fired to approximately 2200°F., the medium-hard samples to 2300°F., and the hard-burn to approximately 2400°F. From each lot, suitable brick were selected for testing.

In Table II, various data based on standard A.S.T.M. tests are shown on samples selected from the three burns.

TABLE II

HANDMADE BRICK

	Burn		
Before reheat	Resets	Medium	Hard
Apparent porosity (%)	26.7	25.4	23.6
Water absorption (%)	13.5	13.1	12.2
Bulk density	1.94	1.94	1.93
Apparent specific gravity	2.65	2.60	2.54
True specific gravity	2.752	2.752	2.742
Modulus of rupture (lb./sq. in.)	526	652	818
Linear change (1400°C. reheat) (%)	+1.08	+0.85	+0.85
After reheat			
Apparent porosity (%)	22.2	22.6	22.6
Water absorption (%)	11.7	11.8	11.9
Bulk density	1.89	1.91	1.89
Apparent specific gravity	2.45	2.48	2.44
True specific gravity	2.754	2.766	2.735

From the data on samples before reheat, it is to be noted that a definite difference in properties exists between the three burns, particularly with respect to the apparent specific gravity.

It is interesting to note that when brick from the three burns receive the same heat-treatment in the high-temperature reheat the porosity and related figures are almost identical. It might be assumed that refractories fired at varying kiln temperatures would eventually become stable and show practically identical properties when installed in installations operating at temperatures of 1400°C. or at temperatures slightly above the firing temperature of the hard-burned brick.

The modulus of rupture data are included to show the effect of variations in firing temperatures on the strength of handmade brick.

Booze and Phelps[3] found that when expansion occurred in hard- and soft-burned brick those which were soft burned expanded much more than those which had been hard burned. In Table II, this fact is confirmed by the average linear change shown by brick from the three burns.

From the fact that the medium-hard- and hard-burned samples show equal changes it may be assumed that a slight difference in firing temperature does not change the reheat characteristics to any appreciable extent. When the firing temperatures of the brick are lowered, however, a distinct difference in reheat properties is to be expected.

The true specific gravity data indicate that only slight changes resulted from the high-temperature reheat. The resets and medium-hard groups showed a slight increase and the hard-burned samples showed a slight decrease.

(2) Dry-Press Brick

The dry-press samples were obtained in a manner similar to that outlined on the handmade brick. They were grouped into resets, medium-hard-, and hard-burned, and identical tests were conducted on typical samples.

[5] S. M. Phelps and J. S. McDowell, "Present Status of Tests for Refractories," *Blast Furnace & Steel Plant*, **17** [6] 910–17 (1929); *Ceram. Abs.*, **8** [8] 582 (1929).

[6] L. J. Trostel, "Symposium on Control Testing in Clay Firebrick Manufacture: XI, Control Testing of Fired Brick from Viewpoint of American Society for Testing Materials Methods," *Bull. Amer. Ceram. Soc.*, **11** [7] 184–86 (1932).

The test brick were fired to approximately the same temperatures as those obtained on the handmade brick, viz., resets 2200°F., medium-hard-burn 2300°F., and hard-burn 2400°F.

A.S.T.M. tests were conducted on the dry-press brick, identical with those conducted on the handmade brick. All data are shown in Table III.

TABLE III
DRY-PRESS BRICK

	Burn		
Before reheat	Resets	Medium	Hard
Apparent porosity (%)	22.7	21.4	21.5
Water absorption (%)	10.7	10.1	10.4
Bulk density	2.13	2.10	2.07
Apparent specific gravity	2.76	2.66	2.64
True specific gravity	2.790	2.802	2.803
Modulus of rupture (lb./sq. in.)	350	720	856
Linear change (1400°C. reheat) (%)	+0.63	0	−0.33
After reheat			
Apparent porosity (%)	20.7	20.3	20.7
Water absorption (%)	10.4	9.8	9.9
Bulk density	2.01	2.07	2.05
Apparent specific gravity	2.54	2.59	2.59
True specific gravity	2.803	2.820	2.803

If the foregoing data are examined, it will be seen that the initial firing temperature of the dry-press brick did not produce any outstanding difference in porosity with respect to the three burns. A very substantial difference is noted, however, between the bulk density and the apparent specific gravity of the groups.

Changes brought about in the standard 1400°C. reheat are similar to those obtained on the handmade brick. The porosities are practically identical and the bulk density and apparent specific gravity figures show a substantial change in properties of the groups.

It is the general opinion that the degree of burn of refractories is reflected in the strength as shown by the modulus of rupture test. In this current work, the modulus test was helpful in selecting brick from the various firing temperatures.

Again it is noted that the brick in the reset category are definitely soft and would not be considered to be a commercial product. It is the general practice to refire such brick. The medium-hard- and hard-burn samples show a definite difference in physical strength.

It is again noted that the reset brick show considerable expansion as compared with the data obtained on the harder-burned brick. The reheat test brings out clearly the effect of various firing temperatures on dry-press brick in relation to linear reheat change.

The true specific gravity data indicate that certain mineralogical changes may have been brought about by the increased temperature of the reheat. There are distinct differences to be noted between the resets and medium-hard-burned brick and a slight difference with respect to the hard-burned samples.

(3) Stiff-Mud Deaired Brick

Samples made by the stiff-mud deaired method of manufacture of refractories were selected in a manner similar to that used for the handmade and dry-press processes. The samples chosen represent the three major burns obtained in rectangular kilns, viz., resets, medium-hard, and hard burn. The reset samples were fired to approximately 2100°F., the medium-hard to a temperature of 2200°F., and the hard-burn to approximately 2300°F.

In Table IV, various data are shown for the three groups of samples after being subjected to the appropriate A.S.T.M. standard tests.

TABLE IV
STIFF-MUD DEAIRED BRICK

	Burn		
Before reheat	Resets	Medium	Hard
Apparent porosity (%)	24.1	18.5	16.6
Water absorption (%)	11.6	8.5	7.7
Bulk density	2.07	2.16	2.13
Apparent specific gravity	2.73	2.65	2.56
True specific gravity	2.761	2.762	2.763
Modulus of rupture (lb./sq. in.)	610	1313	1616
Linear change (1400°C. reheat) (%)	+1.18	+2.16	+1.04
After reheat			
Apparent porosity (%)	17.4	15.0	15.1
Water absorption (%)	8.7	7.1	7.1
Bulk density	2.01	2.11	2.12
Apparent specific gravity	2.43	2.48	2.50
True specific gravity	2.754	2.760	2.784

The data in Table IV indicate that the reset brick were definitely underfired and would not be shipped as commercial brick. The test results obtained on the medium-hard- and hard-burned brick indicate that sufficient heat was applied to develop satisfactory properties in the burned brick.

Data on the samples after reheating show that the reset brick did not approach the properties of the other two burns. This fact might indicate that stiff-mud deaired brick, if somewhat underfired, would not be equal in service to a product which was fired to a somewhat higher temperature. For instance, after the 1400°C. reheat, the medium-hard- and hard-burned brick have almost identical properties, whereas the reset brick show somewhat different characteristics and no doubt would require several reheat treatments to produce properties similar to those noted on the other two groups of samples.

From the foregoing data it is seen that the reset brick fall into the correct category with respect to fired strength. The difference obtained between the medium-hard- and hard-burned samples may be attributed to a difference in firing temperature.

Previously in this paper it was mentioned that when hard- and soft-burned brick were subjected to the standard 1400°C. reheat the soft brick expanded much more than the hard-burned samples. The reheat test data on the stiff-mud brick are not in accord with this generalization. Owing to the low original temperature of firing obtained on the resets, it is probable that appreciable shrinkage did not occur in the original firing but resulted only after the samples were exposed to higher temperatures and that expansion followed this shrinkage. The correctness of this reasoning could be proved by a draw trial. It should be mentioned that the original measurements on the reset samples show that they were somewhat larger in size than the samples from the other two burns.

The data show a decrease in true specific gravity in the resets and medium-hard groups and an increase in the hard-burn samples.

(4) Superduty Brick

The standard A.S.T.M. reheat test for superduty brick specifies that the brick be held at 1600°C. (2912°F.) for 5 hours. Samples were selected in a manner similar to that followed for the high heat-duty brick. The reset samples were fired to 2600°F., the medium-hard to a temperature of approximately 2650°F., and the hard-burn to approximately 2700°F.

Test data are shown in Table V.

TABLE V
SUPERDUTY BRICK

	Burn		
Before reheat	Resets	Medium	Hard
Apparent porosity (%)	20.5	18.7	18.8
Water absorption (%)	9.8	8.6	8.7
Bulk density	2.13	2.18	2.16
Apparent specific gravity	2.68	2.68	2.66
True specific gravity	2.729	2.741	2.730
Modulus of rupture (lb./sq. in.)	457	605	643
Linear change (1600°C. reheat) (%)	−0.85	−0.78	−0.18
After reheat			
Apparent porosity (%)	12.0	12.2	12.3
Water absorption (%)	5.3	5.4	5.6
Bulk density	2.23	2.23	2.19
Apparent specific gravity	2.53	2.55	2.49
True specific gravity	2.690	2.693	2.707

From Table V it is noted that a moderate difference in strength was obtained between the medium-hard- and hard-burned brick and that a substantial reduction in strength was obtained on brick set to receive a soft or reset burn.

The data show a considerable difference in porosity between reset brick and those which received a harder burn and little difference between the medium-hard- and hard-burned brick.

After being subjected to the 1600°C. reheat, the samples from the various burns have almost identical properties. It might be assumed that superduty brick fired at varying kiln temperatures would eventually show identical properties when placed in installations operating at or slightly above the firing temperature of the hard burned brick.

The linear changes bring out definitely the effect of firing temperatures on superduty dry-pressed brick.

From Table V it is also noted that the 1600°C. reheat brought about a substantial reduction in the true specific gravity values of all groups, with the hard-burn samples showing slightly less change.

(5) Silica Brick

In general, there is no standard reheat test procedure specified for silica brick. If desired, however, the standard tests on fire-clay refractories may be applied to check the quality and degree of burn. Porosity and related properties are important when a study is made of the properties of this refractory. A reheating test may also be useful in determining if complete conversion has taken place during the initial firing of the brick. Modulus of rupture data may or may not give information on the fired properties of the brick.

Sample silica brick for this study were set in round downdraft kilns in such a manner as to receive various burns. These burns will be designated as high-temperature or regular, medium, and low. The low-temperature samples were fired to cone 17, the medium-burn to cone 19², and the high-temperature or regular to cone 19 flat.

A testing procedure similar to that used for the fire-clay brick was outlined for the silica brick, except that the high-temperature reheats were conducted at 1550°C. for 8 hours. All data are shown in Table VI.

TABLE VI
SILICA BRICK

	Burn		
Before reheat	Low	Medium	High
Apparent porosity (%)	28.7	30.0	28.2
Water absorption (%)	17.5	18.6	17.1
Bulk density	1.64	1.61	1.65
Apparent specific gravity	2.31	2.31	2.30
True specific gravity	2.322	2.325	2.322
Modulus of rupture (lb./sq. in.)	1085	1000	1171
Linear change (1550°C.) (%)	+0.04	+0.07	+0.04
After reheat			
Apparent porosity (%)	28.1	29.1	28.6
Water absorption (%)	16.8	17.6	17.2
Bulk density	1.66	1.64	1.65
Apparent specific gravity	2.32	2.32	2.32
True specific gravity	2.329	2.329	2.328

Data from Table VI indicate that the low and medium burns produced brick of similar strength, whereas the modulus of rupture of the regular burn shows the effect of somewhat higher kiln temperatures.

The high-temperature reheats produced no appreciable change in the various properties of any of the groups. The true specific gravity determinations check well with the apparent specific gravity data showing that the three groups of samples contained a minimum of closed pores.

VI. Summary

Changes in the various properties of fire-clay and silica refractories as the result of high-temperature reheating may be summarized briefly as follows:

(1) The standard reheat test will not eliminate underfired first-quality firebrick if the product exhibits the property of secondary expansion. Additional tests will be required to determine whether this is true of brick that do not show this expansion.

(2) With first-quality brick showing secondary expansion, those made by the stiff-mud deaired process will show the greatest expansion, handmade somewhat less, and dry-press the least. Brick of harder burn will show less expansion than those of lighter burn.

(3) First-quality and superduty brick, after the standard reheat test, assume almost identical properties irrespective of original firing temperature.

(4) Underfired superduty brick showing no secondary expansion may sometimes be eliminated by the reheat test but not always.

(5) Tests conducted on silica brick fired originally to cones 17, 19², and 19 and subsequently reheated to 1550°C. indicate that the properties are stable when tested at temperatures higher than the original firing temperatures.

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DECOLORIZING POT GLASS*

By S. R. Scholes

Abstract

The principles of decolorizing are reviewed and the influence of the iron content of raw materials, the oxidizing or reducing agents in the batch, the chemical and physical decolorizers, and the possible substitution of other reagents for restricted chemicals are discussed.

I. Introduction

The esthetic sense demands that colorless or crystal glass should be as truly free from visible color as it can possibly be made. Now that the vogue of definitely colored glassware for table use is in temporary eclipse, attention is focused more than ever on the production of "good color," by which the glassmaker means colorlessness.

II. Color Perception

Something should be said at the outset about the sensitivity of the human eye for color and its relation to the means of lighting used in the inspection of ware. White light, considered as the total visible, is made up of vibrations comprising nearly one octave of frequency, with wave lengths ranging from about 400 mμ, the deepest visible violet, to something beyond 700 mμ, the darkest visible red. The keenness with which the eye can perceive light varies widely in different regions of the spectrum. The color band in the yellow-green, or wave lengths near 550 mμ, represents the peak of visual acuity. Hence it is that very faint green or yellow-green color in glassware is easily detected.

The relative proportions of this color band in different sources of illumination naturally affect judgment in the selection of ware for good color. Incandescent lamps give much less violet and more yellow-green than daylight; the arc light is rich in violet and poorer in yellow-green; some fluorescent lamps approximate daylight. Glassware should be criticized under a lighting condition related to that where it will be used; for example, ware may seem to have good color in daylight and a green tint under the incandescent lamps or the candles of a dining room. It is necessary to carry color that looks "high," or on the violet side, in daylight, if the ware is to look well in ordinary home lighting.

III. Effect of Iron

It is a well-known fact that the presence of iron in raw materials causes glass to have a green tinge unless some means is taken to improve the color. This art, known as decolorizing, is very old. The first material used for this purpose undoubtedly was manganese dioxide. The old name for this material, "pyrolusite," is derived from root words meaning essentially fire and wash; that is, it was the means by which color could be washed from the glass at high temperatures. The discovery of the use of manganese for decolorizing cannot be traced, but it must have been the result of trying everything until something useful was found.

Decolorizing may now be accomplished in two ways, although a combination of both is the usual practice. These methods are known as chemical and physical decolorizing. Chemically, the coloring power of iron may be weakened a great deal by converting the iron into the more highly oxidized or ferric condition. Physically, decolorizing is a masking process in which the green or yellow-green color is concealed by the presence of some substance or substances that would by themselves produce a complementary purple or violet color.

The ideal way of producing glass free from color, now practiced by the makers of optical glass and by a few manufacturers of very fine glassware, is to use materials whose iron content is so low that practically no color is thereby produced. While this is not feasible for most plants because of the high cost of superlatively pure materials, it ought to be emphasized in this discussion that relative purity of materials, watchful care against contamination, and separation and discarding of all cullet to which a great deal of iron scale from pipes and tools may adhere should be standard practice.

IV. Physical Decolorizing

For reasons that will appear later, decolorizing, particularly physical decolorizing, is necessarily an imperfect process. In general, decolorized glass is not actually as transparent as that in which no masking reagent has been used, that is, the so-called "crystal glass" is not water-clear and colorless. All that has been accomplished is to cause the glass to transmit all colors equally so that no one color predominates. The higher the iron content, the stronger must be the masking coloration; the consequence is that an attempt to cover up more than a few hundredths per cent of iron oxide produces a glass that is so gray as to be dark in any appreciable thickness.

The origin of color in glass, as in any transparent material, is the selective absorption of light by some of the

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dissolved constituents. Fortunately, the common oxides entering into the usual glass composition do so without exerting this selective absorption. They transmit all wave lengths of visible light equally well. Just as most of the solid reagents on the chemist's shelf are present as colorless crystals, so most of the solid elements may be expected to yield colorless silicate solutions. Only a few of the elements exhibit this selective absorption.

Selective absorption must result in selective transmission. That is to say, if a solution of iron oxide in glass should absorb only 5% of a green band, 20% of a red band, 30% of a violet band, and so on, it necessarily follows that the glass would have, on this account, 95% transmission in the green, only 80% in the red, and 70% in the violet. Consequently, the eye, observing a preponderance of green, sees the glass only as green. As the content of iron increases, the green color is apparently intensified. Actually, less green light reaches the eye than before, but as a result of the physical laws governing light transmission, the amount of red and violet that is let through decreases more rapidly than the amount of green, so that the physiological effect is a great increase in the amount of greenness.

An example may make this more clear. If twice the concentration of iron necessary to produce the effect mentioned above should be present in the glass, the transmission of red will be only $0.8 \times 0.8 = 0.64$; the transmission of the violet will be $0.7 \times 0.7 = 0.49$; while the transmission of green becomes $0.9 \times 0.9 = 0.81$. Now, instead of transmitting only one eighth more green than red and only two sevenths more green than violet, the glass with double the iron content transmits nearly 50% more green than red and 60% more green than violet.

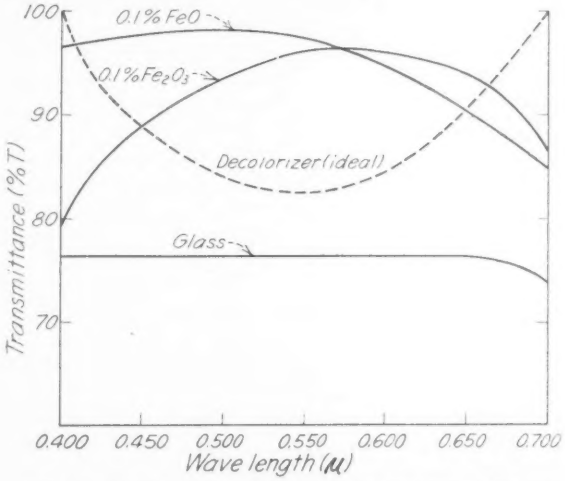

FIG. 1.—Showing transmittances (reflectance being neglected) of 0.1% each of ferrous and ferric iron and calculated transmittance of ideal physical decolorizer required to bring the total transmittance to approximate uniformity over visible range (the "glass" graph) at 76.5%. The state of affairs is purposely exaggerated; in practice, total iron content might be 0.04% instead of 0.2%, which would bring minimum transmittance up to 95% for equal thickness with over-all transmission at 87%. Graphs of such practical values would be so crowded that they would not illustrate clearly the principle involved.

Emphatically, the glass colored green by iron, as this illustration should indicate, does not transmit green to the complete exclusion of other colors but only in relatively greater proportion. The intermediate color bands or wave lengths which have been mentioned are affected in a similar manner, so that the behavior of the glass toward the complete spectrum of color is best described by the well-known transmission curve (Fig. 1). The smooth character of this curve and its freedom from sudden dips and peaks is the best picture of the effect of any substance on color. The problem of decolorizing, from this point of view, is one of combining the curve for iron with that of one or two other substances which will have greater transmission where iron has less and vice versa. The net, ideal result of the combination is a transmission curve for the finished glass that will be nearly a straight line, horizontal in direction, without peaks and hollows. Here again, the transmission at any wave length will be the product of the transmission that would be shown by each of the separate color elements. The net over-all transmission of the glass is, consequently, lowered, although, visually, no color predominates, and the product may be regarded as "crystal glass."

V. Chemical Decolorizing

The masking of color, or physical decolorizing, has been discussed. It is at least equally important to consider the effectiveness of chemical decolorizing. By this is meant the establishment of an oxidizing condition in the melt whereby the iron is maintained in the higher state of oxidation, or ferric condition. Ferric iron has relatively feeble coloring power. It makes the glass straw color or yellow-green, whereas ferrous iron produces a green to blue-green color. Unfortunately, heat alone is sufficient to separate part of the oxygen from ferric oxide, so that, in the absence of some source of oxygen from reagents in the glass, at least part of the iron will be in the ferrous condition.

The problem is to find the means of maintaining an oxidizing condition. It is clear that any oxidizing agent, by its very nature, must be one that will yield its oxygen to the surrounding material, and it cannot be permanent. The best type of reagent that can be hoped for is one that will not rapidly be decomposed by high temperature alone, while it still has sufficient oxygen potential to give oxygen to ferrous iron. Arsenic pentoxide seems to be the most reliable, as it is the classical reagent for this purpose. Entering the batch as white arsenic (the trioxide), arsenic takes on added oxygen from niter and remains as a powerful stabilizing chemical. When it is not available, a completely satisfactory substitute may not be found.

Cerium oxide has been proposed, and reports have indicated that it has some effect as a carrier of oxygen. It must be emphasized again that no oxidizing agent can be permanent. When its equivalent of available oxygen has been used up, it can be of no further value in the melt.

Antimony oxide might be expected to behave similarly because of the close relationship of these two elements. Antimony trioxide, however, takes on more

oxygen all too eagerly and holds it too firmly as it becomes tetroxide or perhaps pentoxide. Instead of acting as an oxidizer for iron, it may even have the opposite effect.

The conditions of pot melting are favorable for the maintenance of oxidation. Flame gases are excluded from contact with the melt, so that occasional excess fuel gas in the furnace atmosphere cannot rob the glass of oxygen. The temperature is not nearly as high as in the tank. Finally, any oxygen driven from the melting batch constituents has a good chance of remaining as part of the atmosphere of the pot, which thus becomes to some extent oxidizing.

VI. Choice of Decolorizers

Manganese dioxide serves both as a physical and as a chemical decolorizer. It gives up one fourth of its oxygen quite readily to any oxidizable substance, such as ferrous iron, or even under the influence of high temperature alone. The writer believes that the resulting manganese sesquioxide (Mn_2O_3), or trivalent manganese, is the form in which this element colors the glass purple. But manganese in this condition is still an oxidizing agent, easily reducible to the manganous form, represented by MnO. This form is without coloring action, and several per cent of MnO may be present in a virtually colorless glass as a result of a reducing condition.

When a nice balance between the quantities of iron oxide and manganese has been reached, it seems that the color of the glass should be a light straw. This means that all of the iron is ferric, and practically all of the manganese has become manganous. The amount of manganese dioxide necessary to produce this condition cannot be estimated from the iron content of the batch because of the indeterminate effect of heat on all these metallic oxides. A slight excess of manganic (trivalent) manganese causes the absorption of some of the straw color due to ferric iron. In general, cobalt is a necessary supplement, as a "bluing" to cover the remaining trace of yellow.

As every glassmaker knows, the amount of cobalt needed is much less when potash forms a major part of the alkali present. In the presence of much potassium, the manganese ion absorbs more strongly in the yellow and transmits more strongly in the blue region, whereas, in glasses where sodium predominates, the green absorption and red-violet or purple transmission prevail.

A similar difference may be observed in the behavior of nickel. In a soda glass, the absorption by nickel is so distributed over the visible spectrum that a general darkening results with only somewhat higher transmission in violet and red. Nickel is not a suitable decolorizer for soda glasses. In a potash glass, nickel produces a much more marked blue-violet effect and covers the iron color with fair success.

Finally, neodymium oxide, marketed as neodymium oxalate, has an absorption quite complementary to that of iron and is an effective decolorizer. The main objections to its use are its high cost and the fact that pure preparations are difficult to obtain. Among the possible elements present as impurities with neodymium is praseodymium, which has a green ion and which offsets the work of the neodymium.

VII. Summary

The conditions that produce well-decolorized glass are (1) purity of raw materials, (2) presence of oxidizers, and (3) proper amounts of complementary colorants.

Conditions operating against good "color" are (1) iron in raw materials or "tramp" iron, (2) carbonaceous material in batches or cullet, (3) high temperature, and (4) slow melting or long standing in the pot.

Decolorizing is a cut-and-try process, which succeeds best when established conditions are repeated as closely as possible from melt to melt.

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FLOTATION OF TALC*

By Hemming Franz

Abstract

The flotation of talc as practiced by the Eastern Magnesia Talc Company is discussed.

I. Location

The flotation plant of the Eastern Magnesia Talc Company is located at Johnson, Vermont, forty miles east of Burlington and forty miles south of the Canadian border.

II. Mining

The deposit was discovered in 1902 and has been worked since 1904. The ore body consists of vein talc near the walls which gradates into a talc and magnesite core. The bulk of the crude ore mined is this mixture of talc and magnesite.

All production is from underground. The deposit is opened up by a 45-degree inclined shaft sunk to a depth of 200 feet. This shaft connects with an 8- by 8-ft. level, at present 1400 feet in length, with open stopes and pillars to near surface. Haulage is by storage-battery locomotive in 1-ton cars. Earlier production was from workings since abandoned.

III. Crushing

Ore is hauled in 7- and 8-ton trucks $5\frac{1}{2}$ miles from the mine to a 100-ton coarse-ore bin at the mill. A 15- by 24-inch jaw crusher with a rotary crusher in series crushes

* Presented at the Forty-Sixth Annual Meeting, The American Ceramic Society, Inc., Pittsburgh, Pa., April 4, 1944 (Materials and Equipment Division). Received April 19, 1944; revised copy received October 9, 1944.

the mine rock to a $-1/2$ inch. This material is conveyed to three 425-ton storage silos from which it passes to one of three 25-ton dry-mill feed bins.

IV. Dry Grinding

There are three separate grinding units in the dry-mill section, viz., a 5-roller high-side mill, a 36-inch vertical emery mill, and an 8-foot by 36-inch pebble mill.

In closed circuit with the 5-roller high-side mill is a whizzer separator. By using a speed reducer with the whizzer separator, the screen test of the product can be varied to meet the demands of the customer. Crude ore or tailing from the mill circuit, or a combination of the two, is used as feed to this grinding unit. The roller mill is also used to grind flotation concentrates.

The discharge from the 36-inch vertical emery mill passes to a 6-foot separator which produces either No. 40- or No. 41 grade talc. The reject from this separator goes to an 8-mesh trommel screen, the undersize mixing with the rejects from the first separator in the pebble-mill circuit and the oversize joining the feed to the pebble mill. Crude rock is generally used as feed to the vertical emery mill.

The pebble-mill feed is usually a mixture of crude ore and the oversize rejects from the vertical emery-mill circuit. The discharge passes to a 7-foot separator which produces No. 41-grade talc; the rejects from this separator go to a 6-foot separator where the feed to the flotation section is recovered.

V. Flotation

The material which is now used as feed for the flotation plant was at one time of marketable grade. The volume of sales of this product gradually declined, however, and, as this grade constituted half of the pebble-mill production, or about 35 tons a day, the problem of disposing of this material became acute. As this product had a high percentage of talc and the management had noted a gradual market trend toward the use of better-grade talcs, it was decided to try some test runs to determine the feasibility of a flotation process.

After considerable experimenting, in 1937 a flotation plant was added to the dry-mill section to recover the talc from the pebble-mill-circuit rejects. These rejects average 50% talc and have a screen test of 70 to 75% through 200-mesh. The 35 tons of feed originally sent to this plant daily have proved to be inadequate and tailing from the vertical emery-mill separator has been added to the pebble-mill circuit to bring the feed up to 40 to 45 tons per day.

The dry-mill rejects are carried by screw conveyer to a 12-ton feed bin. A dry feeder passes the dry material to a conditioner. Water is added to make up the conditioner discharge at 35% solids.

The conditioner discharge splits over two tables with the concentrates combining. The tailing from the one table is pumped to a 3-cell flotation machine. Reagent is added to the pump. The tailing from the second table is pumped to an 8-cell flotation machine. Reagent is also added to the pump of this circuit. The table concentrates are recovered for their nickel-cobalt values. A middling product from the tables is wasted.

Flotation feed is at 20% solids and 88% -200-mesh.

The concentrates from all cells of both machines combine and are pumped to a thickener. The flotation tailing passes to waste.

VI. Dewatering and Drying

The feed to the thickener averages 18% solids. The underflow is maintained at 35 to 40% solids. If it rises above 40% solids, the filter cake is lumpy and too heavy for efficient drying. The thickener overflow goes to waste.

The thickener underflow is pumped to a rotary filter. One segment of this filter blows below the scraper edge. The cake is scraped off and not blown to maintain a low moisture content (about 12 to 15%).

Filter cake is carried by a conveyer to a drier, which is equipped with a drum-type combustion chamber and an oil burner. Fuel-oil consumption is 17 gallons per ton of material dried. The temperature of the material discharged varies from 225° to 280°F. The drier feed rate is 1 ton per hour.

The drier discharge is carried by screw conveyer, bucket elevator, and Roto-Clone to the dry-mill section for grinding in the roller mill, or to a vertical high-speed mill for reduction to No. 549-, H–500-, or M–500-grade talc.

VII. Flotation Production

The flotation plant produces about 14 to 15 tons per day of concentrates averaging 88 to 92% talc testing about 92% through 200-mesh. The tailings discarded amount to 25 to 30 tons daily, averaging 30 to 35% talc. A better percentage of recovery could be possible with a production of 10 tons per day, but to satisfy the present expanded market for this high-grade talc the flotation section is being operated temporarily beyond its most efficient point.

The high iron content of the talc precludes its use as a substitute for low-iron steatite. An analysis of the crude talc shows 4 to 5% iron. All except 0.5% of the acid-soluble iron is removed by tabling in the flotation process. There still remains, however, 2.0 to 2.5% iron chemically combined with the talc.

Oliver Ralston of the U. S. Bureau of Mines has stated that if the iron content is chemically combined in the talc, as in the so-called "green" talc, the iron cannot be removed without destroying the talc. He considered the Vermont talc to be in this category where the removal of iron by ordinary leaching is not feasible.

When the flotation plant was still in its early stages, it was hoped to recover all the value from the feed by making three products, viz., a talc, a magnesite, and a nickel-cobalt concentrate. A talc and a nickel-cobalt concentrate are being recovered, but the magnesite concentrate has so far proved to be nonmarketable, mainly because of the high iron content; the material averages 12% ferric oxide.

Owing to Government restrictions which have closed many customs smelters, the market for nickel concentrates has been lost. At the present time, more than 100 tons of concentrates, consisting of iron, nickel, and cobalt sulfides and averaging 10 nickel, 0.7 cobalt, and 32 to 37% iron, are on hand. These concentrates are still being recovered, but at a greatly reduced rate.

A middling product was collected formerly from two tables and this material was pumped to a table where additional nickel-cobalt concentrate was recovered, but be-

cause of the surplus concentrate on hand and limited storage space this phase of operation has been abandoned.

VIII. Laboratory Analysis

A small laboratory is maintained for mill control. Particle sizing is done on standard screens within their range size and on the turbidimeter in the micron size.

The chief concern is obtaining as white a product as possible. To do this, the dark, heavy minerals (iron, nickel, and cobalt sulfides) must first be eliminated by tabling and then the talc content must be increased by flotation. The routine laboratory testing therefore is for talc content of the flotation concentrates; this is done by chemical analysis to determine the acid-insoluble.

Several more complete analyses, however, have been made of the flotation feed, flotation concentrates, and table concentrates. An average analysis of each of these is given in Table I.

IX. Shipping

Most of the products in the screen sizes are shipped in paper bags, the largest portion being shipped in valve bags, fifty pounds to a package. Some shipments, however, are made in burlap bags, especially small freight shipments, and occasionally a bulk shipment is made.

The high-speed mill products are shipped in paper bags or in paper-lined burlap.

X. Grades and Uses

Grades range from a finely pulverized flotation concentrate (99.99% through 325-mesh) to a coarse dry-mill tailing which tests about 20% −200-mesh. These products go into a large variety of industries, e.g., the paper, rubber, paint, roofing, textile, insecticide, cosmetic, and ceramic industries.

TABLE I

	Flotation feed (%)	Flotation concentrate (%)	Flotation tailing (%)	Table concentrate (%)
Talc	52.0	90.0	32.0	
$MgCO_3$	38.0	5.0	58.0	
$CaCO_3$	0.15	0.15	No analysis	
Al_2O_3	1.2	0.25	" "	
Total iron as FeO	6.2	3.2	" "	
Acid-soluble iron as FeO	3.7	0.5	" "	
Fe				35.0
Ni				10.0
Co				0.7
Mg				2.5
Al				3.5
S				27.0
As				1.5

Acknowledgment

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EASTERN MAGNESIA TALC COMPANY
JOHNSON, VERMONT

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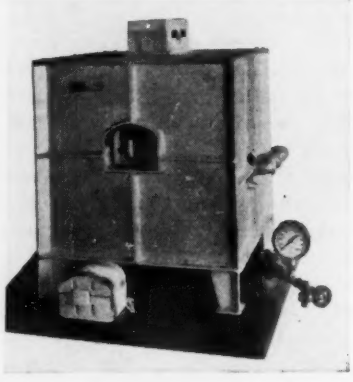

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SYMPOSIUM ON "REVIEW OF ENAMEL TESTS"*

R. L. Cook, *Presiding Chairman*

I. TESTS CONCERNING THE METAL AND THE PREPARATION OF METAL SURFACES FOR PORCELAIN ENAMELING

By W. W. Higgins

Abstract

A résumé is given of information found in the ceramic literature concerning the metal and the preparation of metal surfaces for porcelain enameling. Brief résumés are given of those tests which seem to be favored in the literature as doing their respective "jobs."

I. Introduction

The following brief résumé of tests concerning the metal and the preparation of metal surfaces for porcelain enamel covers only information found in the ceramic literature, and no attempt is made by the writer to set forth test recommendations, but rather to point out those tests which seem to be favored in the literature as doing their respective "jobs."

II. Sag Tests

The writer found very little in the ceramic literature concerning physical property tests suggested and used by the porcelain enameler on the iron and steel with the exception of sagging tests. The first article on the subject was by Butts in 1932.[1] This was followed in 1935 by a shop test described by Aydelott and Pfeiffer.[2] In 1938, Porter[3,4] fully described a laboratory test method for measuring sag-resisting properties of enameling iron or steel, and finally a tentative standard test for measuring this property was set forth by the Porcelain Enamel Institute in 1940.[5]

All such tests reported consist basically of supporting strips of enameling iron at one end, or at both ends, and heating the strips and supports to a specific enameling temperature for a definite period of time. The amount of the resulting sag after the treatment is taken as a criterion of the sag resistance of the material. The tentative standard of the P.E.I. for this property took into account all the test variables that were known at that time.

A brief résumé of the P.E.I. sag test might be stated as follows:

A light alloy rack or frame is required for supporting the specimens at the ends during the sag test, giving an unsupported span of 10 inches.

The furnace used must have close temperature control. A calibrated thermocouple is used for measuring the temperature of the furnace and should be placed in close proximity to the specimens during test. A protective shell of 16-gauge heat-resisting alloy is used in the furnace to protect the zone in which the samples are heated from the furnace heat source and thus assure more uniform temperature conditions.

A special micrometer measuring device is used for finally measuring the sag of the test specimens.

Three 2- by 12-inch test specimens are cut from the middle of the sheet being investigated and the average of their sag is taken as the amount of sag for the sheet in question.

After the test specimens are cleaned, pickled, and neutralized in the conventional manner, the thickness of the stock is carefully measured, a ground coat of porcelain enamel is then applied to both sides, and after drying the enamel is brushed away from the area on the specimens which will contact the firing supports.

The specimens are then placed on the cold firing rack or frame and placed in the furnace under the carefully controlled conditions previously described. They are heated for 10 minutes at 1600°F. After cooling, the sag is measured.

III. Metal Surface Tests

One physical property of metal, its surface roughness, is mentioned in the literature because of its important bearing on enamel pickup in dipping and slushing applications and its ultimate effect with regard to the bond of the fired enamel. No test, however, for measuring the degree of surface roughness before or after metal surface preparation was suggested. Perhaps this important property could be studied and a test arrived at through the use of a profilometer* or surface analyzer.† Such instruments are currently being used by metal fabricators and finishers when the degree of surface roughness of the metal surface is of utmost importance. These instruments consist essentially of a combination of a stylus pickup arm, a cali-

* Presented at the Forty-Sixth Annual Meeting, The American Ceramic Society, Inc., Pittsburgh, Pa., April 4, 1944 (Enamel Division). All papers received October 2, 1944.

[1] C. H. Butts, "Checking Sag-Resisting Properties of Enameling Iron," *Better Enameling*, **3** [6] 21 (1932); *Ceram. Abs.*, **11** [12] 607 (1932).

[2] E. C. Aydelott and W. H. Pfeiffer, "Enamel Shop Control," *Better Enameling*, **6** [3] 12–17 (1935); *Ceram. Abs.*, **14** [6] 133 (1935).

[3] F. R. Porter and J. H. Nead, "Characteristics of Iron and Steel for Porcelain Enameling," *Jour. Amer. Ceram. Soc.*, **21** [1] 9–16 (1938).

[4] F. R. Porter, "Factors Affecting Sag-Resistance Properties of Enameling Iron," *Proc. Porcelain Enamel Inst. Forum, Third Forum, Oct., 1938*, pp. 47–54; *Ceram. Abs.*, **18** [6] 148 (1939).

[5] "Tentative Standard Test for Sagging of Iron and Steel Sheets for Porcelain Enameling," Porcelain Enamel Institute, 1940.

* Profilometer Co., Ann Arbor, Mich.

† Brush Development Co., Cleveland, Ohio.

brating amplifier, and a direct-inking oscillograph which will accurately indicate surface irregularities of less than one millionth of an inch. Such an instrument shows the number of irregularities within a certain area as well as their direction.

Such a test might be valuable in studying the "as-received" condition of enameling iron or steel sheets as well as the degree and type of etch of the finally cleaned and pickled surface.

IV. Cleaning and Pickling Control Tests

(1) Testing Alkali Cleaner Bath

It has been common practice to test alkali cleaner baths for available alkali content by titration of a 10-cc. sample of the cleaner bath with *N* sulfuric acid solution to a phenolphthalein end point. Continuation of this titration to a methyl orange end point gives the so-called "total alkali" content.

Comparison of these results with those obtained on a control sample of freshly made cleaner is then used as a "rule-of-thumb" method of determining whether the cleaner bath is up to "cleaning" strength.

Some writers have expressed the results of these titration tests as so-called "activity factors." For such calculation, the cubic centimeters of acid used in titration to the phenolphthalein end point is divided by the total cubic centimeters of acid used to the methyl orange end point.

Benoliel,[6] Hansen,[7] Zander,[8] and others point out, however, that this test is only a tool to be used in conjunction with the test cleaning of control samples in the cleaner bath in question.

Zander[8] recently pointed out that, owing to the complexity of the various reactions carried out in the cleaning bath, which include saponification of the fats and vegetable oils, emulsification of the mineral oils and greases, plus the principles of wetting power, detergency, saturation, surface tension, and rinsability, more complex testing of the cleaner bath was needed.

(2) Testing Sulfuric Acid Pickle Bath

Two tests are in most cases used for testing the pickling bath, viz., its acid strength and iron content.

For acid content, a representative 10-cc. sample of the bath is titrated with a 2.04 *N* sodium hydroxide solution to a methyl orange end point, this being taken as the change of the titrated sample from red to a straw-yellow color if the iron content is low enough not to interfere with seeing this end point. If the iron content causes precipitation of a dirty green-colored iron precipitate, the end point is taken as that point where this precipitate starts to form.

If 2.04 *N* sodium hydroxide solution is used for titration, the cubic centimeters of acid are equivalent in per cent to the strength of acid present in the sample. Thus, if 7.5 cc. of acid were used in the titration, the pickling acid is 7.5% sulfuric acid.

The iron content is determined by titrating a 10-cc. sample of the pickle bath which has been strongly acidified with sulfuric acid with a 0.0895 *N* potassium permanganate solution until a faint pink color appears and remains. Each cubic centimeter of potassium permanganate solution used represents $^1/_2$% of iron in solution.

Taylor[9] suggested the use of potassium dichromate solution for this titration several years ago, but most writers cited potassium permanganate solution as the one most prominently used.

(3) Testing Nickel Dip or Strike Bath

Hansen,[10] Andrews,[11] Pettyjohn,[12] Kautz,[13] Zander,[14] and others point out that two control tests are particularly needed for the best performance of the nickel dip or strike bath. These consist of tests for nickel content and the pH of the bath.

The testing of the nickel bath for nickel content can and is in most cases done by chemical titration methods with the following group of so-called standard solutions: (1) standard nickel salt, (2) ammonium citrate, (3) standard potassium cyanide, (4) standard silver nitrate, and (5) potassium iodide. Standardization of a standard nickel solution through titration gives its true nickel content. By comparing these results with the titration results of the unknown bath, its nickel content is established.

Kautz[13] suggests the use of a colorimetric comparison as a means of determining nickel content and found only an error of plus or minus $^1/_2$ ounce per gallon in this method. Such a method is, of course, much more rapid than the determination of nickel content by chemical methods.

The pH of nickel strike or dip solutions can be checked through the use of a glass electrode-calomel cell pH meter, a Block comparator, or pH paper indicators.

The glass electrode-calomel cell pH meter probably gives the most accurate results and readings directly in pH. For rapid results that are accurate enough, however, pH papers used much in the same fashion as litmus paper will do the job. The Block comparator uses color comparison against standard samples as the means for determining pH.

(4) Testing Neutralizer Bath

The neutralizers generally used are checked by titration in much the same manner as the cleaner bath, except that its dilute nature calls for a larger original sample. Generally a 100-cc. sample is titrated with *N* sulfuric acid solu-

[6] D. J. Benoliel, "Drawing and Cleaning Compounds," *Proc. Porcelain Enamel Inst. Forum, Second Forum, Oct., 1937*, pp. 51–56.

[7] J. E. Hansen (editor), Manual of Porcelain Enameling. Enamelist Publishing Co., Cleveland, Ohio, 1937; *Ceram. Abs.*, **17** [2] 59 (1938).

[8] J. M. Zander, "Changes Occurring in a Cleaner Bath During Use," *Better Enameling*, **13** [4] 17–19 (1942).

[9] R. K. Taylor, "Methods of Determining Iron in Pickling Acid," *Amer. Enameler*, **9** [5] 23–24 (July–Aug., 1936); *Ceram. Abs.*, **16** [1] 8 (1937).

[10] J. E. Hansen and J. T. Irwin, "Use of a Nickel Dip in Enameling Practice," *Jour. Amer. Ceram. Soc.*, **18** [8] 225–29 (1935).

[11] A. I. Andrews, Enamels. Twin City Printing Co., Champaign, Ill., 1935. 410 pp.; *Ceram. Abs.*, **14** [7] 158 (1935).

[12] James Pettyjohn, "Nickel Dip Treatment of Enameling Iron," *Proc. Porcelain Enamel Inst. Forum, Second Forum, Oct., 1937*, pp. 56–61; *Metal Cleaning & Finishing*, **9** [12] 995–98 (1937); *Ceram. Abs.*, **17** [7] 245 (1938).

[13] Karl Kautz, "Double vs. Single Nickel Salts in Nickel Dipping Practice," *Enamelist*, **15** [4] 13–15, 60–63 (Jan., 1938).

[14] J. M. Zander, "Factors Affecting Rate of Nickel Deposition in Nickel Pickling," *Better Enameling*, **9** [6] 5–8, 25–26 (1938); *Ceram. Abs.*, **19** [8] 183 (1940).

tion to a methyl orange end point. In such a titration, each cubic centimeter of acid used represents 0.031% sodium oxide content.

V. Summary

This brief résumé of the tests concerning the metal and the preparation of metal surfaces for porcelain enameling shows the need for the development and adoption of various standard tests in this phase of porcelain enameling processing. Such standard tests could and should be developed and adopted in the Enamel Division of The American Ceramic Society.

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II. REVIEW OF TESTS FOR FINENESS AND CONSISTENCY OF ENAMEL SLIPS

By C. M. Andrews

Abstract

Various methods for testing the fineness and consistency of enamel slips are reviewed. These methods are described and compared for their practicability in plant control.

I. Introduction

It is well known that careful control of slip properties is essential for efficient enamel application. To intelligently control these properties, it is important that particle size and slip consistency be determined.

Variations in fineness are known to affect slip consistency, draining properties, firing characteristics, and opacity.

Slip consistency must be determined and controlled because of its effect on the uniformity of application and quality of the finish.

Enamel slips which act like plastic materials require an applied force to start their flow. The force necessary to start this flow is called the yield value and the rate of flow is called the mobility. The yield value of the slip is an indication of its draining weight and mobility indicates its water content. As these two components can be measured, it is possible to determine and control the consistency of enamel slips.

The literature has been reviewed for these various test methods. In evaluating the test which will be described, it should be kept in mind that if a control test method is to be successful it must (1) be simple and easy to run, (2) be dependable, and (3) supply the desired information.

II. Test Methods for Determining Fineness

(1) Screen Tests

The most common tests for determining the fineness of enamels slips are the screen methods. These various tests are essentially the same but differ in the sample used and the basis upon which the per cent of fineness is calculated.

In 1930, the Enamel Division accepted the screen test which designated that 100-gram equivalent of frit be taken as the sample.[1] The slip is passed through a 40-mesh screen onto a 100-, 200-, or 325-mesh screen, depending upon the predetermined amount of residue. If the residue is greater than 25 grams on a 200-mesh screen, a 100-mesh screen should be used. Quantities of 1 to 25 grams on a 200-mesh screen may be tested on that size. The sample is washed until water passing through is clear. The residue is then dried until it moves freely on the screen and is shaken until not more than $^1/_{10}$ gram passes through after one minute of continued shaking. The residue remaining on the screen is weighed and the weight in grams is equivalent to per cent of the original 100 grams of frit.

The screen test accepted by the Porcelain Enamel Institute differs only in the sample used. In this test, 100 grams of slip are taken and the residue on a 200-mesh screen is expressed as per cent of the original weight of slip.

(2) Settling Test

This test is based on the fact that in a given medium the rate of settle of particles in suspension is dependent upon the particle size. By Stokes' law

$$V = \frac{2r^2g(d_p - d_m)}{9k}$$

V = rate of settle (cm./sec.).
r = radius of particles (cm.).
g = gravity constant.
d_m = density of medium.
d_p = density of particle.

The settling test may be performed as follows[2]: 70 cc. of distilled water are measured into a stoppered graduate; add 3 cc. of sodium silicate solution (2 parts 40° Bé. diluted with 3 parts of water) and fill to the 100-cc. mark with the slip to be tested; 0.1 gram of red oxide may be added to aid in distinguishing the amount of settle. The stoppered cylinder is shaken for 10 to 15 seconds and placed on a level table. The enamel is allowed to settle for two minutes and the amount of settle read to the nearest 0.1 cc. The temperature of the suspension is important, as the volume of settle increases with a temperature increase. It has been found that 0.1 cc. of settle should be added for every degree under the temperature set as a standard and subtracted for every degree over the standard. The fineness is then determined by referring to curves which show the relationship between volume of settle vs. residue on a 200-mesh screen.

Under ordinary shop conditions, allowances for slight variations in specific gravity are not necessary. The in-

[1] "Report of Enamel Division Standards Committee, 1930," *Bull. Amer. Ceram. Soc.*, **9** [9] 269–71 (1930).

[2] M. H. Whitehead, "Use of Settling Test for Determination of Fineness of Porcelain Enamels," *Proc. Porcelain Enamel Inst. Forum, Fourth Forum, Oct., 1939*, pp. 105–13; *Ceram. Abs.*, **19** [7] 157 (1940).

fluence of variable solid mill additions may also be considered negligible.

Electrolytes have various effects on settling. Acid salts up to 1/8% have no effect, up to 1/4% the effect is about 0.2 cc., and over 1/2% upsets the results completely. Basic or neutral salts, with the exception of the hydroxides, have no effect.

The chief advantage of this test is that it can be made quickly.

The hydrometer test for fineness is also based on Stokes' law.[3] Hydrometer readings are taken at various intervals during the settling period. Particle-size distribution may also be determined by this method.

III. Consistency Tests

It has previously been stated that enamel slips act like plastic materials and therefore require a force to start their flow. This force and the rate of flow or mobility may be determined by various methods.

(1) Bingham Plastometer

An early method for determining slip consistency was that of measuring the force necessary to start the flow through a capillary tube as well as the rate of that flow by means of the Bingham plastometer.[4,5] The Bingham plastometer consists of a glass flow tube about 90 cm. long by 1.3 cm. wide, graduated in 10-cc. divisions. A capillary tube of a known radius is inserted in this tube. The tube is filled with slip and the rate of flow is determined at various intervals. Three to five intervals will usually be sufficient for plant control. The force or shearing stress applied on the column of slip at these intervals can be calculated by

$$F = \frac{RhDg}{2l}$$

R = radius of capillary.
h = average effective ht. of slip.
D = density of slip.
g = gravitational constant.
l = length of capillary.

When these forces in dynes per cm.^{2} are plotted against the rate of flow in cc. per sec., the result is a straight line. The point at which this line intersects the abscissa is the yield value of the slip and the slope of the line is the mobility. The greater the slope the higher the mobility.

In plant control, this method may be simplified and calculations may be eliminated by plotting the rate of flow against the effective head in centimeters. The results obtained by this method, however, give relative yield value and relative mobility.

(2) Irwin Consistometer

The Irwin consistometer, a modification of the Bingham plastometer, consists of a flow tube with two capillaries of the same diameter but different lengths inserted in the bottom.[6] Two marks calibrated to include 50 cc. of slip are marked off on the flow tube on either the upper or lower part of the tube, depending upon the consistency of the slip to be tested. The time for the slip to flow between these two marks is noted as well as the volume passing through each capillary.

From these data the rate of flow through each can be calculated. As the radius of the capillaries, the effective height of slip, and gravitational constant are the same in each case, Rhg in the shearing stress formula may be expressed as the constant K. Then $F = \frac{KF}{2l}$. Thus two points are established on the graph in one operation.

This test has the advantage of being faster and easier to perform than the Bingham plastometer method.

(3) Gardner Mobilometer

The Gardner mobilometer is a cylinder supported by a base plate, a plunger, and a bracket to support the plunger.[7] The plunger consists of a perforated disk and a weight pan attached to the upper end of a brass tube.

The cylinder is filled to a predetermined mark with the slip to be tested. The disk is forced through the slip by a definite weight on the plunger, and the time required for two marks 10 cm. apart on the stem to pass through the collar is recorded. Taking a fresh sample of slip for each determination, several weight loads may be used and the results may be plotted as force in grams against the rate of travel in centimeters per second. This graph gives relative yield value and mobility.

The disadvantages of this method for determining slip consistency are (1) that it requires very careful technique for consistent results and (2) there are discrepancies in results owing to different degrees of agitation of enamel slips which are thixotropic in nature.

(4) Pressure Flow, Hydrometer, and Viscosity Tube

The consistency of an enamel slip may be indicated by determining the time required to force a standard volume through an orifice by carefully controlled air pressure.[8] The apparatus consists of a small pressure tank, an outlet with a carefully machined orifice, and a pressure-control system which includes two regulators and a mercury gauge for fine adjustments. The pressure is usually fixed at 2 1/2 lb. per sq. in. and the time required to fill a standard measure is recorded.

Some work has been done on the use of hydrometer readings as a test for set.[9] It has been found that the yield value and hydrometer readings are closely related and that specific gravity and mobility have little effect on set. With this method, it is possible to establish a mathematical relationship between hydrometer readings and the pickup value in any one set of data, but this relationship will not

[3] J. C. Reimers, "Application of Hydrometer Method of Fineness Analysis to Porcelain Enamel Slips," *Bull. Amer. Ceram. Soc.*, **18** [6] 195–200 (1939).

[4] W. N. Harrison, "Controlling Consistency of Enamel Slips," *Bur. Stand. Tech. Paper*, No. 356, 34 pp. (Sept. 30, 1927); "Vitreous Enamel Slips and Their Control," *Jour. Amer. Ceram. Soc.*, **10** [12] 970–94 (1927).

[5] R. D. Cooke, "Plastic Properties of Enamel Slips," *Jour. Amer. Ceram. Soc.*, **7** [9] 651–55 (1924).

[6] J. T. Irwin and R. E. Bevis, "Modification of the Bingham Plastometer," *ibid.*, **21** [2] 66–68 (1938).

[7] G. H. McIntyre and J. T. Irwin, "Application of Gardner Mobilometer to Enamel Slip Studies and Controls," *ibid.*, **15** [8] 433–38 (1932).

[8] Jack E. Trees, "Flow Test for Porcelain Enamels to Be Sprayed," *Enamelist*, **16** [4] 28–31 (Jan., 1939); *Ceram. Abs.*, **19** [5] 108 (1940).

[9] H. L. Cook and C. H. Wolff, "Effect of Set of Enamels on Hydrometer Readings of Slip," *Jour. Amer. Ceram. Soc.*, **25** [2] 51–52 (1942).

hold true on another set. It cannot be classed, therefore, as a shop method.

Many plants use a viscosity tube or viscosimeter for controlling slip consistency. Reiss contends that each enamel viscosity has a definite specific gravity at which best dipping consistency is found.[10] By plotting viscosities against specific gravities at best working consistencies, a hyperbolic curve may be drawn, along which the best working properties of a slip may be determined.

IV. Specific Gravity, Pickup, and Rate of Set

The specific gravity of a slip can be easily found by weighing a unit volume.

The pickup method or weight per unit area can be found by dipping either a pickled plate or a ground-coated plate in the slip and allowing it to drain in a vertical position. This method should be standardized, as Harman and Johnson have shown that the manner and rate of withdrawal of the test plate from the slip affects the pickup weight.[11]

The rate of set may be determined by measuring the time required for the enamel to set on the ware after being placed on the dip rack.

These tests have been very popular in plant control because they simulate operating conditions. As the specific gravity of a slip gives the water content, it is a very definite indication of the mobility. The rate of set is also an indication of the mobility. A short drain time indicates high mobility and a long drain time indicates low mobility.

V. Discussion of Tests

(1) Fineness

The American Ceramic Society screen test, based on a sample equivalent of 100 grams of frit, is used primarily for research, as it is undoubtedly the most correct. This method has not been generally used for plant control because of the variation in the size of the sample required.

In the more practical Porcelain Enamel Institute screen test, the standard sample used is 100 grams of slip. It must be realized, however, that any appreciable change in water content of the slip will affect the results by increasing or decreasing the amount of frit in the sample.

The settling test can be used advantageously for fineness control in plants where time is an important factor.

(2) Consistency

It has previously been stated that an enamel slip is thixotropic in nature. A substance is thixotropic when it can be transformed from a gel to a sol by mechanical agitation.[12] Thus, the degree of agitation to which a slip has been subjected influences the results obtained in the various tests for consistency.

The consistency tests which find the most favor in plant control are those which quickly indicate the characteristics of the slip as it is being used. If it becomes necessary to make adjustments, time is an important factor. Tests which require graphs for interpretation are oftentimes too slow. If standards are set on each type of enamel slip used in a particular plant, the pickup, viscosity tube, and specific gravity tests may be safely used as indications of yield value and mobility. The more precise methods for measuring slip consistencies are often used, however, as periodic checks on the practical methods.

In any control method, standardization of procedure and care in performance are necessary for consistent and accurate results.

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[10] Max Reiss, "Relation of Specific Gravity, Viscosity to Dipping Consistency of Enamel," *Ceram. Ind.*, **41** [3] 34–36 (Sept., 1943); *Ceram. Abs.*, **23** [2] 36 (1944).

[11] (*a*) C. G. Harman and H. C. Johnson, "Factors Involved in Glaze-Slip Control: III, Additional Glazes and Improved Technique and Apparatus," *Jour. Amer. Ceram. Soc.*, **27** [7] 209–14 (1944).

(*b*) C. G. Harman and H. C. Johnson, "Factors Involved in Glaze-Slip Control: IV, Practical Uses for Coherence Value and Receptivity Measurements," *ibid.*, pp. 214–20.

[12] A. I. Andrews, Enamels. Twin City Printing Co., Champaign, Ill., 1935. 410 pp.; *Ceram. Abs.*, **14** [7] 158 (1935).

III. REVIEW OF THE TEST METHODS USED TO DETERMINE SOME OF THE PHYSICAL CHARACTERISTICS OF PORCELAIN ENAMELS WHEN APPLIED TO IRON AND STEEL

By F. A. Petersen

Abstract

Tests to determine the resistance of an enamel coating to abrasion, impact, and acid attack and tests used to determine the bond between the enamel and metal are discussed.

I. Introduction

Various types of tests which have been used for determining the resistance of enamel coatings to impact, abrasion, and acid attack, as well as bond or adherence tests, will be discussed. It is the purpose of this review to familiarize those present with the different types of tests which have been used in the past.

It is very important that control tests be used in the industry, as this is one way whereby a constant check can be kept on the quality of the ware being produced. These tests also play an important role in the development of new and more versatile enamels which can broaden the field of application of porcelain enamels.

II. Acid-Resistance Tests

The utility of enameled objects is especially dependent upon the resistance of the coating to attack by acids. If an appreciable amount of solution takes place, the gloss of the coating is destroyed and one of the greatest advantages of porcelain enamel, ease of cleaning, is lost.

Many acid-resistance tests* have been used in this industry, but they can be broken down into the following groups: (1) grain test, (2) loss-in-weight test, (3) weight-of-residue test, and (4) spot test.

The tests within each group vary in the acid used, the temperature of the test solution, the concentration of acid, and the length of time of attack. To obtain comparable results, these conditions must be standardized.

(1) Grain Test

The grain test consists of placing a weighed sample of powdered enamel in an acid solution of specified strength for a set length of time. The enamel remaining is then reweighed to determine the weight loss, which is taken as an index of the acid resistance of the enamel. This test can be used in the testing of enamel frits, but is not readily applicable to the testing of enamel coatings to acid attack.

(2) Loss-in-Weight Test

This test consists of weighing an enameled plate or shape, after which the enameled surface is exposed to acid attack for a predetermined length of time. The test specimen is then carefully rinsed, dried, and reweighed and the loss-in-weight is reported in terms of weight per unit area exposed to the acid solution.

Tests of this type are best adapted to the testing of enameled utensils or as a quantitative test for determining the acid resistance of enamels in general.

(3) Weight-of-Residue Tests

This type of test is similar to the loss-in-weight test, differing only in that the weight of material dissolved from the enamel is determined. The residue which is weighed is obtained by first evaporating the solution to dryness, then either chemically ashing or igniting the residue to eliminate the organic material present. The extent of the acid attack is reported as the weight of residue per square unit of area exposed to the acid solution.

The chief objection to tests of this type is the length of time involved in obtaining the results. This type of test has been used primarily in the testing of enameled utensils.

(4) Spot Test

When using the spot test, a few drops of acid are placed on the enameled surface to be tested, and after a set length of time the surface is washed, dried, and inspected. The appearance of the attacked area is indicative of the resistance of the coating to attack.

The latest modification of the test classifies the attacked area as one of several groups, depending upon the appearance of the treated area, the ease with which a pencil mark can be removed from the treated area, and the appearance of an image observed as a high light, as it passes into the treated area.

This is a very good qualitative test, is rapid and easy to use, and has been widely used in the enameling industry.

* A bibliography covering acid-resistance tests has not been included inasmuch as a complete bibliography will be included in a paper presented by R. L. Cook and A. I. Andrews ("Chemical Durability of Porcelain Enamels,") to be published at a later date in the *Journal of The American Ceramic Society.*

III. Abrasion Tests

Porcelain enamel coatings are, as a rule, very resistant to surface abrasion, but there are factors which can definitely reduce this quality. It is, therefore, necessary to use abrasion tests which bring out these differences so that the resistance of the coatings to abrasion can be controlled and improved.

Scott[1] and Harrison[2] describe a method for determining the abrasion resistance of glazes. The test consists of allowing standard sand to fall onto the specimen, which is stationary and inclined to the stream of sand. Scott uses the loss-in-weight of the specimen after a specified period of test as an index of the abrasion resistance of the specimen. Harrison measured the gloss of the specimen with an Ingersoll glarimeter before and after test and states the results as the weight of sand necessary to reduce the gloss of the sample 10%. Kinzie[3] describes a test in which the test specimen, an enameled cup, is coated on the inside with the enamel to be tested. The cup is weighed and charged with predetermined amounts of water, cleaning powder, washing powder, and 1/4-inch porcelain balls. The open end of the cup is fitted with a rubber gasket and a steel plate, and the cup is then attached to the end of a horizontal shaft. After rotating at a speed of 63 r.p.m. for 41 hours, the charge is removed and the cup is rinsed, dried, and reweighed. The loss-in-weight of the cup is reported as the abrasion resistance of the enamel tested. Schramm[4] tested glazed plates which were rotated in front of a sandblast nozzle for a predetermined period. The loss-in-weight of the plate indicates the abrasion resistance of the coating. Andrews[5] reports a method which consisted of rotating a disk, to which the test plates were attached, in a box containing 10-mesh silicon carbide. The loss-in-weight of the specimens was reported as an index of the resistance to abrasion. A comparison of the surfaces of the test pieces after treatment was also used. Spencer-Strong[6] determined both surface abrasion and destructive abrasion. This test consisted of propelling standard sand against the stationary test panel by revolving disks. The gloss of the test panels was measured before and after test with an Ingersoll glarimeter, and the loss of gloss after treatment with a set weight of abrasive was used as an expression of the resistance to surface abrasion. Resistance to destructive abrasion was reported as the weight of sand necessary to abrade the coating until the iron was exposed. Sparks[7]

[1] W. J. Scott, "Apparatus for Measuring Abrasive Hardness of Glazes," *Jour. Amer. Ceram. Soc.*, **7** [5] 342–46 (1924).

[2] A. C. Harrison, "Preliminary Study of Resistance to Abrasion of Ceramic Glazes, Its Control and Methods of Determination," *ibid.*, **10** [2] 77–89 (1927).

[3] C. J. Kinzie, "Physical Tests for Vitreous Enamels: I, Determining Physical Properties of Vitreous Enamels," *ibid.*, **12** [3] 188–92 (1929).

[4] Edward Schramm, "Sandblast-Abrasion Test for Glazes," *ibid.*, [5] 356–59.

[5] A. I. Andrews, Enamels, p. 364. Twin City Printing Co., Champaign, Ill., 1935. 410 pp.; *Ceram. Abs.*, **14** [7] 158 (1935).

[6] G. H. Spencer-Strong, "Some Experiments in Development of a Sand-Abrasion Machine," *Jour. Amer. Ceram. Soc.*, **19** [4] 112–15 (1936); *Amer. Enameler*, **10** [1] 10–11, 26 (March, 1937).

[7] Evelyn Sparks, "Household Cleaning Powders Scratch Porcelain Enamel," *Enamelist*, **19** [3] 8–13 (1941); *Ceram. Abs.*, **21** [5] 99 (1942).

tested a series of enameled plates using different cleaning powders to determine the relative destructive effect of the powders. The test equipment used was an electric mixer in which the beaters were replaced by a padded scrubbing disk. The enameled plates were mounted against the pads after the pads were moistened with water and coated with a weighed amount of the cleaner to be tested. The mixer was run for a set length of time and the test surface after cleaning was inspected. The relative resistance to abrasion was determined by comparison. The Porcelain Enamel Institute[8] has devised a test for determining the abrasion resistance of enameled plates. The test plates are placed in holders, to which is added measured quantities of standard feldspar, water, and rust-resisting alloy balls $^5/_{32}$ inch in diameter. A set of test units is then placed in a Ro-Tap which oscillates the specimens for a predetermined length of time. The gloss of the specimens is determined before and after treatment and the per cent of original specular gloss which is retained is an index of the resistance of the enamel to abrasion.

IV. Impact Tests

Impact tests are used in the enameling industry to obtain an indication of the resistance of enamel coatings to physical abuse.

These tests can be classified into two general groups, according to the method used in striking the ware, viz., the falling-weight and pendulum tests.

Falling-weight methods have been described by several authors.[9] This method consists primarily in dropping a weight onto the test specimen from varying heights until fracture of the coating occurs. The results are expressed in terms of the energy necessary to cause fracture or the height of drop of the impacting weight to cause fracture. The test methods differ in the weight of the impacting object and the point of impact on the specimen being tested.

Pendulum-type machines have been described by various authors.[10] In this type of test, the test specimens are struck by a hammer which is part of a pendulum. Each successive blow is increased until failure occurs. Here again the variations in test equipment are the weight of the pendulum and the point at which the test specimen is struck.

The design of the test specimens, and other variables, such as thickness of enamel, rigidity of support of the test specimen, and rigidity of the machine, can all cause variations in the results obtained.

V. Bond Tests

The determination of the bond between the enamel and the metal base has always been a very difficult task. This has been true to a great extent, as it is difficult to design test equipment to determine a property when the character of the property is not known.

Bond tests are classified in two groups, depending upon whether or not the metal is deformed. Two tests are described in which the metal is not deformed. Harrison and Thaler[11] and Andrews[12] discuss tests in which two enameled specimens are pressed together during firing and then cooled slowly. The specimen is then placed in a tensile testing machine and the force necessary to pull the specimens apart is given as a value for the adhesiveness of the enamel to the metal. One objection to the test is that the fracture takes place in most tests within the enamel layer rather than at the interface and is, therefore, not a determination of the adherence of the enamel to the metal.

Several writers[9(a)(c), 13] describe a method in which a heavy weight is dropped onto the surface of the enameled specimen so as to deform the metal. The impacted area is then inspected and the amount of enamel adhering to the metal is an indication of the adherence of the enamel to the metal. Landrum[13(a)] weighed the plates before and after the test and used the loss-in-weight as an indication of the adherence.

Tetrick[13(c)] judged the adherence by the appearance of the impacted area and also by the appearance of a specimen after it had been sharply bent through ninety degrees. Kinzie[14] describes a method in which an arbor press fitted with a plunger in contact with a steel ball is used. The test specimen is clamped in place with the ball resting on the enamel surface. The plunger is then brought down a predetermined distance, pressing the ball onto the enameled sheet which is deformed. The adherence is judged by examination of the deformed area. This test always gives the same size of deformed area regardless of metal gauge, which is an advantage. Sams[15] introduced a method in which the enameled test specimen is stretched in a tensile testing machine to a predetermined extent. The stretching

[8] "Test for Resistance of Porcelain Enamels to Surface Abrasion," Porcelain Enamel Institute, March, 1942.

[9] (*a*) Edward Orton, Jr., "Notes on Testing of Enameled Sheet Steel Ware," *Trans. Amer. Ceram. Soc.*, **11**, 320–41 (1909).

(*b*) "Impact Test on Enameled Steel Bathtubs," *Amer. Enameler*, **9** [3] 14 (May, 1936).

(*c*) J. E. Hansen (editor), Manual of Porcelain Enameling, pp. 360–61. Enamelist Publishing Co., Cleveland, Ohio, 1937; *Ceram. Abs.*, **17** [2] 59 (1938).

(*d*) G. H. Zink and A. I. Andrews, "Enameled Utensil Manufacturers' Council Tentative Standard Impact Test for Porcelain Enameled Cooking Utensils," *Bull. Amer. Ceram. Soc.*, **22** [8] 283–86 (1943).

[10] (*a*) R. R. Danielson and B. T. Sweely, "Relation Between Composition and Properties of Enamels for Sheet Steel," *Jour. Amer. Ceram. Soc.*, **6** [10] 1011–29 (1923).

(*b*) H. G. Wolfram and W. N. Harrison, "Effects of Composition on Properties of Sheet Steel Enamels," *ibid.*, **8** [11] 735–55 (1925).

(*c*) R. H. Turk, "Comparison of Results Obtained with an Impact Machine," *ibid.*, **13** [11] 887–93 (1930).

(*d*) H. H. Holscher, "Vitreous Enamel Impact Machine," *ibid.*, **15** [6] 353–57 (1932).

(*e*) "Impact Test for Laboratory Specimens of Porcelain Enameled Sheet Iron and Steel," Porcelain Enamel Institute, August, 1940.

[11] W. N. Harrison and G. T. Thaler, "Test for Adhesiveness of Vitreous Enamels to Metal," *Jour. Amer. Ceram. Soc.*, **11** [11] 803–811 (1928).

[12] A. I. Andrews, p. 356 of footnote 5.

[13] (*a*) R. D. Landrum, "Comparison of Ten White Enamels for Sheet Steel," *Trans. Amer. Ceram. Soc.*, **14**, 489–509 (1912).

(*b*) Anson Hayes, "Reboiling of Enamels and Tests for Adherence, III," *Better Enameling*, **4** [3] 13–14 (1933); *Ceram. Abs.*, **12** [7] 254 (1933).

(*c*) J. D. Tetrick, "Study of White Ground Coats," *Jour. Amer. Ceram. Soc.*, **17** [11] 349–56 (1934).

[14] C. J. Kinzie and J. B. Miller, "Method for Testing Adherence of Ground Coats to Metal," *Bull. Amer. Ceram. Soc.*, **14** [11] 371–73 (1935).

[15] J. E. Sams, "Stretch Testing—a New Method of Measuring Attachment of Porcelain Enamel to Sheet Metal," *Proc. Porcelain Enamel Inst. Forum, Fifth Forum, Oct., 1940*, pp. 73–89; *Ceram. Abs.*, **20** [4] 86 (1941).

fractures the enamel and the tested specimens are compared. The adherence is determined by comparing the degree of attachment of enamel in the stretched areas. This test also eliminates the effect of metal gauge. This is fundamentally the same as the other tests, as in deforming the metal in the other, the metal is stretched. The main difference is that in Sam's test the elongation is relatively uniform over the entire test area, whereas in the other tests it is not. Cress and Fisk[16] suggest a test for enameled cast iron. The specimen is compressed in a regular test machine until fracture of the enamel takes place. The results are reported as the force necessary to cause the initial fracture of the enamel and the force necessary to remove 50% of the enamel. A comparison can also be made of the appearance of the base metal of several specimens after the enamel has been removed.

[16] W. C. Cress and H. G. Fisk, "Proposed Test for Adherence of Enamel to Cast Iron," *Bull. Amer. Ceram. Soc.*, **23** [3] 123–25 (1944).

VI. Summary

All of the tests mentioned must be carefully controlled and the condition under which the tests are run must be standardized to obtain comparative results. Many variables enter into the production of the test specimens, and any or all of them can have some influence on the results obtained.

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IV. TEST METHODS USED IN STUDYING THE PROPERTIES OF ENAMEL FRITS

By R. L. Cook

Abstract

The various test methods which have been used in studying the properties of enamel frits are reviewed. These tests include the fusion properties by cones, glass rods, fusion block, button cylinder, and interferometer, as well as other physical properties such as viscosity, surface tension, and strength and elasticity.

I. Introduction

In reviewing the various tests used in studying the physical properties of enamel frits, the fusion tests will be considered as a group and the other tests will be considered separately.

II. Fusion Properties of Frits

(1) Deformation Temperature of Enamels by Cones

The method of determining the deformation[1] temperature of an enamel by means of cones is one of the two standard tests of the Enamel Division. In this test, a sample of frit or milled enamel is ground to pass a 150-mesh sieve. The test piece is made in the shape of a pyrometric cone, $^5/_8$ inch on the base and $2^1/_2$ inches high, by molding the powdered enamel with water and an organic binder. The cones are mounted in a clay base so that they are equidistant from a thermocouple and are placed in a furnace which is capable of accurate temperature control. The cones are subjected to a definite rate of heating and the temperature is noted at which the initial bending of the tip occurs and also noted at the final bending of the tip to touch the base. This test does not give very reproducible results and is not used extensively.

(2) Deformation Temperature of Enamels by Glass Rods

A recent modification of the foregoing test is recorded by King and Andrews[2] in which glass rods 3.25 cm. long and 0.5 mm. in diameter were mounted at a 60-degree angle in a rigid base, heated for one hour, and the temperature noted at which the glass rod would bend over and flatten out so that the rod touched the base along its entire length. In a similar test, the temperature was determined at which the tip of the glass rods would just touch the base. In this test, the viscosities of the enamel glasses were correlated with the viscosity of known soda-lime-silica glasses. This test appears to give desirable characteristics which can be used in studying and developing experimental compositions.

(3) Fusion Block Test

In the fusion block test,[3] a specially prepared porcelain inclined block is used. The powdered enamel is packed into the space above the incline. The block is then placed in the furnace and heated at a uniform rate. The temperatures are taken at the start of flow and at the time the enamel passes each intersection on the incline. The temperature at which the enamel reaches the lowest intersection is usually taken as the fusion temperature. At the present time, the fusion block test is not used very widely in enamels.

(4) Button Cylinder Test[4]

This method consists of heating pellets of the enamel glass on a panel placed horizontally for a sufficient period of time to cause softening of the glass; the panel is then changed to a vertical position with the result that the en-

[1] "Report of Enamel Division Standards Committee," *Bull. Amer. Ceram. Soc.*, **9** [9] 269–71 (1930).

[2] B. W. King, Jr., and A. I. Andrews, "Viscous Properties of Soda-Boric Oxide-Silica Glasses at Temperatures from 900° to 1500°F.," *Jour. Amer. Ceram. Soc.*, **23** [8] 232–35 (1940).

[3] W. N. Harrison and B. J. Sweo, "Some Fusion Properties of Ground-Coat Enamels as Influenced by Composition," *Bur. Stand. Jour. Research*, **10** [2] 189–209 (1933); R.P. 524; *Ceram. Abs.*, **12** [5] 181 (1933).

[4] A. I. Andrews, Enamels, p. 330. Twin City Printing Co., Champaign, Ill., 1935. 410 pp.; *Ceram. Abs.*, **14** [7] 158 (1935).

amel flows down the vertical surface. In this method, 60- to 80-mesh enamel is made into cylindrical pellets 1/2 inch in diameter and one inch high. They are placed on a panel in a horizontal position and heated for three minutes, then lowered to a vertical position and allowed to remain in the furnace for ten minutes. This test is probably used more widely in studying the fusion characteristics of enamel frits than any other test. In fact, it might be desirable for the Standards Committee of the Enamel Division to consider writing definite specifications for this button cylinder test.

(5) Interferometer

In determining the coefficient of expansion of enamel glasses by means of the interferometer, the expansion curve reverses when the enamel begins to soften. The temperature at which the curve reverses can be used in determining the fusion of enamels. This is a very satisfactory test, but it requires special equipment and is rather time consuming, which tends to limit its field of application.

III. Viscosity

The published literature pertaining to tests other than fusion tests used in determining the physical properties of frits is quite meager. Within the last few years, an extensive study of the physical properties of several frits has been made at the National Bureau of Standards.

Harrison, Stephens, and Shelton[5] studied consistency or viscosity of several representative commercial frits at and near their firing temperatures by means of a small rotation viscometer. In this equipment, a platinum cup, which contained the molten frit, was revolved by a variable-speed electric motor. A hollow platinum spindle, which was suspended from above, was immersed in the molten frit during a test and the amount of torque transmitted from the revolving cup to the spindle by the test material was measured by means of a suitable mirror and scale. The speed of rotation of the cup was varied at each temperature and the corresponding viscometer deflection was determined. From these tests, it was shown that some frits act as simple viscous liquids, whereas others, particularly those containing dissolved or suspended matter, behave as complex liquids.

IV. Surface Tension

A method of measuring the surface tension of enamel frits is described by Harrison and Moore[6] in which the pull on a hollow vertical cylinder, touching the molten liquid at its lower end, is measured with a torsion balance. The platinum-5% iridium cylinder, which is 2.5 cm. in diameter and whose walls are 0.01 cm. thick, is suspended from a pulley on the torsion wire by an Alumel wire chain. In calibrating the equipment, the cylinder is replaced by a weight pan and the relationship between known weights applied and the degree of twist in the torsion wire are determined. The test liquid is contained in a platinum-5% iridium dish (7.5 cm. in diameter by 2 cm. deep). The test is carried out in a furnace capable of careful temperature control. It was reported that the surface tension of the different enamel frits did not vary widely and that at and near firing temperatures of the enamel frits the temperature did not affect the surface tension appreciably.

V. Strength and Elasticity

Determinations have been made of the tensile strength, modulus of rupture, and modulus of elasticity on a few enamel frits. Harrison, Shelton, and Wadleigh[7] describe a method used in determining these various physical properties of ground-coat enamel frits. In another investigation, Moore and Harrison[8] used a similar method in which enamel fibers were drawn by hand from the molten frit contained in a platinum crucible. The fibers were started with a round nickel rod, the temperature being adjusted to give fibers between 0.65 and 0.85 mm. The length of the specimens for the modulus of elasticity tests was about 12 cm. and for the strength tests about 4 cm. The fibers were annealed in a laboratory test furnace by heating for 15 minutes at about 5°C. above the softening point as determined on the interferometer and then cooling slowly.

(1) Modulus of Elasticity

In the modulus of elasticity test, the fiber rests on a fixed span of 9.1 cm. A small aluminum pan was suspended by a fine wire from the midpoint of the span. The deflections were observed with a micrometer microscope when a load was applied in the pan. The modulus of elasticity was then calculated from the formula

$$E = \frac{FL^3}{12\pi Dr^4}$$

E = modulus of elasticity.
F = load.
L = length of span.
D = deflection.
r = radius of circular rod.

(2) Modulus of Rupture

In the study of the modulus of rupture of the enamel frits, tests were run under both (*a*) sustained loads and (*b*) uniformly increasing loads. In the tests with the uniformly increasing load, the stress was applied at the center of the specimen on a span of 2.35 cm. The center knife edge was attached to the base of a modified pan balance. The two end supports were suspended from one arm of the balance and moved upward as the load was applied to the opposite arm. The load was applied at a definite rate and the modulus of rupture calculated by the formula

$$M = \frac{8FL}{\pi d^3}$$

M = modulus of rupture.
F = load.
L = length of span.
d = diameter.

[5] W. N. Harrison, R. E. Stephens, and S. M. Shelton, "Consistency of Eight Types of Vitreous Enamel Frits at and near Firing Temperatures," *Jour. Research Nat. Bur. Standards*, **20** [1] 39–55 (1938); R.P. 1063; *Ceram. Abs.*, **17** [4] 134 (1938).

[6] W. N. Harrison and D. G. Moore, "Surface Tension of Vitreous Enamel Frits at and near Firing Temperatures," *Jour. Research Nat. Bur. Standards*, **21** [3] 337–46 (1938); R.P. 1133; *Ceram. Abs.*, **18** [1] 13 (1939).

[7] W. N. Harrison, S. M. Shelton, and W. H. Wadleigh, "Strength and Young's Modulus of Some Ground-Coat Enamels for Sheet Iron," *Jour. Amer. Ceram. Soc.*, **18** [3] 100–106 (1935).

[8] D. G. Moore and W. N. Harrison, "Effects of Humidity and Composition on Strength and Young's Modulus of Enamels," *Jour. Research Nat. Bur. Standards*, **23** [3] 329–43 (1939); R.P. 1237; *Ceram. Abs.*, **19** [1] 6 (1940).

VI. Summarization of Equipment Available for Testing Various Physical Properties of Enamels

(1) Opacity: (*a*) Hunter multipurpose reflectometer, (*b*) photovolt reflectometer, and (*c*) spectrophotometric photometer.

(2) Thickness of enamel coatings: (*a*) General Electric thickness gauge and (*b*) Magna gauge.

(3) Bond or adherence: (*a*) falling-weight test, (*b*) stretch test, (*c*) National Bureau of Standards impact machine, and (*d*) impact testing equipment for enameled utensils by Enameled Utensil Manufacturers' Council.

(4) Gouge test equipment as designed by the National Bureau of Standards.

(5) Continuity or uniformity of enamel surfaces: (*a*) Cesco tester and (*b*) RCA Jr. volt-ohmyst.

204 Ceramics Building
University of Illinois
Urbana, Illinois

★ LETTERS FROM SERVICEMEN* ★

Petawawa, Ontario, Canada,
25 October, 1944

Dear Dr. Purdy:

I am most happy to be on your mailing list and to receive your interesting letters. After three years overseas, in England and a short session in France, and two years in Canada, I feel somewhat out of touch with ceramics and ceramic developments. Your letters are a welcome link.

Sincerely,
H. L. Watts

★

New York, N. Y.,
13 October, 1944

Dear Dr. Purdy:

I am very glad to receive any data or information in regard to the ceramic industry. I most assuredly intend to go into the industry upon the completion of the war. Professor J. W. Whittemore, Virginia Polytechnic Institute, has been requested by me to send several textbooks that I may not get too rusty in the field. I am looking forward to the first Meeting which I shall be able to attend.

I have seen some ceramic industries in Sicily, Italy, and now in France. I must say their ways are crude in comparison to ours, although interesting to observe.

Yours truly,
William D. Anderson,
Lieutenant, U. S. Army

★

San Francisco, Calif.,
19 October, 1944

Dear Sir:

It was with a great deal of interest that I read your letters, "Ceramics for the Serviceman." I have gotten out of contact rather badly with the publications of The Society. I have kept up on my subscriptions, however, and I am looking forward to the opportunity of being able to sit down after the end of this war and go through all of the publications that have piled up on me since joining the Navy.

Thank you for your interest and for keeping me informed of the more important transactions and meetings of The Society.

Sincerely,
F. R. Elliott,
Lieutenant, U. S. Navy

★

San Marcos, Texas,
31 October, 1944

Dear Dr. Purdy:

Your news letters to ceramists in the service are most welcome. Keep them coming!

A lot of us are pressed for time and find your letters an excellent way to keep abreast of the times because of the wide scope and brevity of those letters.

I feel that the other 375 agree with me.

Thanks for your interest in us.

Sincerely,
Richard P. Kelting,
Private, Army Air Corps

★

Miami, Fla.,
23 October, 1944

Gentlemen:

I was more than pleased to receive your very interesting letter advising me of some of the happenings in the ceramic industry. As you probably remember, I was the ceramic engineer for The Akro Agate Company in Clarksburg, W. Va. Most of my work there consisted of making colored glass, both opaque and transparent. On several occasions, an article in one of your publications enabled me to make improvements on the color and quality of the glass.

There was an article in one of your publications on coefficient of expansion of glass, which was very interesting and helpful because of our having to work two or more types and colors of glass together to obtain the effect desired in variegated glassware, whereupon a slight variation in the coefficient of expansion in any one of the different kinds of glass used together would cause undue breakage.

I have been stationed in Brazil for several months and have made quite an extensive study of the ceramic industry here. The glassware now being made is of a very poor quality, but it is only because of an inadequate supply of the proper chemicals. Most of the glassmakers are Europeans and most of them have a thorough knowledge of glassmaking, but their equipment is very old, so they have to depend on cheap labor to make a profit. Some of the boys operating the hand press and doing other important jobs are only about fourteen years of age.

The refractories used in the glass industry here are of a very fine quality. The clay is obtained in Brazil in unlimited quantities. I could not find out the chemical contents, but it is a known fact from experience that impurities in this clay are practically nonexistent. I saw one glass tank that had been in operation for two and a half years, and very little corrosion could be noticed, although it had been used to melt a glass of a very corrosive nature.

There are many rich mineral deposits in Brazil undeveloped, and it is believed that after the war these mineral deposits will be developed, and we will be able to get a mineral for the American ceramic industry that before we could only obtain in one or two other places in the world.

Do not misunderstand me and think that I am a member of the Chamber of Commerce down here in Brazil, although I admit I have been here long enough to vote for Vargas in case he decides to be elected president some day instead of getting it otherwise. Of course it is up to him to make that decision.

* See also *Bull. Amer. Ceram Soc.*, **23** [11] 434–36 (1944).

I would appreciate your inclosing in your next letter the name of a good ceramic handbook published within the last year or so, and the address where I can obtain this book. I have some extra time once in a while that I could devote to the studying of ceramics, so I will not be too far behind in the new developments when I return to civilian life again.

Thanking the staff of The American Ceramic Society again for the consideration they have shown in the writing of letters to the men in the armed services

I remain
Sincerely,
DENNIS R. BEASLEY,
Staff Sergeant, Army Air Corps

★

Southwest Pacific,
16 October, 1944

Dear Dr. Purdy:

I received your Letter to Servicemen yesterday and I want you to know that it was enjoyed immensely. It was good to hear news of The Society, its future plans, and the doings of some of its members.

I dropped my membership after I had been in the service for one year, only because I was going overseas and I knew it would be difficult to keep in contact.

My former employers (B. F. Drakenfeld), however, keep me fairly well informed as to their particular industry. I hear from Victor Remington and Doctor Shively quite often.

Just as soon as I get back to civilian life you can be assured that I'll be right back in The Society. I know that the industry will grow and there will be some large developments after the war. I don't believe a person could find a more pleasant and congenial group of people than The Society offers.

My six months overseas have passed quite rapidly and considering life is not too bad, although I'm afraid none of the South Pacific islands are as Hollywood and *Esquire* have formerly pictured them. They are all alike, a lot of cocoanut trees, coral, and jungles.

At present I am an artillery observer in a Pack Howitzer Battalion and I am well pleased with the job.

Thanks again for your letter and I shall look forward to any future news letters.

Sincerely yours,
J. A. STEWART,
Lieutenant, U. S. Marine Corps

★

MEMBERS IN SERVICE*

The following members of this Society are in fighting units of war service. There are several in service in Washington not included in this Service Roster. This list, which was begun September, 1942, and added to each succeeding month, is probably not complete, and we would appreciate information on other members.

(380) DAVID L. ARMANT, National Lead Co., Titanium Div., Lewiston, N. Y.
(381) RAYMOND L. CHRISTIAN, JR., Georgia School of Technology, Atlanta, Ga.
(382) F. H. CLOUD, Georgia School of Technology, Atlanta, Ga.
(383) L. W. COUGHANOUR, Massachusetts Institute of Technology, Cambridge, Mass.
(384) ARTHUR J. HAECKER, JR., 21 Gates Ave., Salamanca, N. Y.
(385) ALEXIS J. HANNAN, Rutgers University, New Brunswick, N. J.
(386) ARNOLD G. JOHNSON, Libbey-Owens-Ford Glass Co., Rossford, Ohio.
(387) ARCHIE JOHNSTON, JR., Georgia School of Technology, Atlanta, Ga.
(388) LOUIS KELEM, New York State College of Ceramics, Alfred, N. Y.
(389) FRANK KLANE, University of Illinois, Urbana, Ill.
(390) GEORGE D. MARTIN, North Carolina State College, Raleigh, N. C.
(391) ADDISON MAUPIN, General Refractories Co., Lookout Mountain, Tenn.
(392) RICHARD P. MCCABE, North Carolina State College, Raleigh, N. C.
(393) JOHN G. MONCK, Georgia School of Technology, Atlanta, Ga.
(394) RUSSELL C. NEFF, General Refractories Co., Philadelphia, Pa.
(395) JOHN W. NELLEY, Edgar Thomson Works, Carnegie-Illinois Steel Corp., Braddock, Pa.
(396) RUSSELL PARDEE, Mexico Refractories Co., Mexico, Mo.
(397) LYLE N. PERKINS, Hershey Industrial School, Hershey, Pa.
(398) JAMES PROKOPEC, Corning Glass Works, Corning, N. Y.
(399) W. S. REDMAN, University of Toronto, Toronto, Ontario, Canada.
(400) ROLLIN C. ROSE, Georgia School of Technology, Atlanta, Ga.
(401) HERMAN H. SCHRICKEL, Corning Glass Works, Corning, N. Y.
(402) ALDEN J. SMITH, Knox Porcelain Corp., Knoxville, Tenn.
(403) ANDREW TENCZA, University of Alabama, University, Ala.
(404) PAUL G. THOMPSON, Ohio State University, Columbus, Ohio.
(405) JOHN E. TURNBULL, U. S. Stoneware Co., Akron, Ohio.

* These are in addition to the lists published monthly, beginning with the September, 1942, *Bulletin*, with the exception of the June, 1943, issue.

OUR SERVICEMEN ARE SERVING YOU

**Many of Them Risking Their Lives Flying Over Flak,
Tramping Over Explosive Mines,
Shooting It Out or Bayoneting It Out with Your Enemies**

IS BUYING WAR BONDS FOR INVESTMENT PURPOSES SUFFICIENT?

★ ★ ★

WHAT SHALL I SAY TO THE OFFICIALS OF A PROSPECTIVE CORPORATION MEMBER?

Tell them that The American Ceramic Society needs the prestige of corporation names in its roster

1. To continue and expand its world leadership in ceramics.

2. To express executive approval of the efforts of technical men to advance the art, the science, and the technology of ceramic processing.

3. To support scientific thinking on industrial problems through the publication of papers covering advanced research work.

Tell corporation officers that the backing of their companies is important to The Society so that it may better serve their industry.

Then ask them for a Corporation membership.

PAID MEMBERSHIP AND SUBSCRIPTION RECORD

Date of Record	Members Paid		Deferred	Subscriptions	Monthly Sales	Total Circulation
	Personal	Corporation				
November 21, 1943	2076	303	5	507	220	3111
January 21, 1944	2110	323	4	531	220	3188
October 21, 1944	2261	393	3	605	220	3482
November 21, 1944	2283	398	3	618	220	3522
12-month % increase	10	31.4		21.9		13.2

NEW MEMBERS IN NOVEMBER

Corporation

DIRATS, J., & Co., J. Dirats (voter), Notre Dame St., Westfield, Mass.

FLETCHER ENAMEL CO., J. Carroll Fletcher (voter), Dunbar, W. Va.

HOME AID CONSTRUCTION CO., H. K. Brown (voter), 527 Society for Savings Bldg., Cleveland, Ohio

KOLENE CORPORATION, J. H. Shoemaker (voter), 315 Boulevard Bldg., Detroit 2, Mich.

NONPORITE PTY., LTD., Norman Griffiths (voter), 292-296 Burwood Rd., Hawthorn E. 2, Victoria, Australia

Personal

ALLSHOUSE, HOMER J., 303 Fourth Ave., Derry, Pa.; general foreman, Westinghouse Electric & Mfg. Co.

BURDICK, MILTON D., 5551 Bradley Blvd., Chevy Chase 15, Md.; National Bureau of Standards.

*COSBY, LT. A. B., USNR, 44 E. Clapier St., Philadelphia 44, Pa.

DAUMKE, ARTHUR H., 3629 N. Paulina St., Chicago 13, Ill.; Harshaw Chemical Co.

ETHEREDGE, OTIS K., Gordon, Ga.; chemist.

GOOCHEE, HERMAN, 109 Chamberlain St., Raleigh, N. C.; laboratory engineer, Stupakoff Ceramic & Mfg. Co.

GORDON, SYD LEE, Ceramicenter, Inc., 39 East 35th St., New York 16, N. Y.; director.

GRIFFITH, J. SCOTT, 1118 East 64th St., Chicago, Ill.; Armour Research Foundation.

HERBERT, PAUL R., Sparta Ceramic Co., East Sparta, Ohio; general manager.

LERNER, S. P., 1009 West 7th St., Los Angeles 14, Calif.; Ceramic and Clay Products Co.

LING, MENG-CHANG, c/o Miss Alice E. Traub, 709 North 7th St., Allentown, Pa.; National Bureau of Industrial Research, Chungking, China.

MADDUX, WILLIAM H., 3020 Fletcher Dr., Los Angeles 41, Calif.; art pottery.

MARTIN, LT. GEORGE D., 444 Broadway, Long Branch, N. J.

*MILLER, JOHN B., Third St., Lewiston, N. Y.

MILLER, JORGE S., Casilla 187, Santiago de Chile, South America; chief engineer, Cristalerias de Chile.

MOSTHAF, EDWIN, 363 Lincoln Ave., Orange, N. J.; Henry L. Crowley & Co., Inc.

PAVLIUCHENKO, V. I., Soviet Purchasing Commission, 210 Madison Ave., New York, N. Y.; ceramic engineer.

POLHEMUS, D. WORTH, Lake Shore Dr., Harbor Hills, Ohio; Carborundum Co., Refractories Division.

RHODES, GEORGE L., 428 W. Second Ave., Derry, Pa.; general foreman, Westinghouse Porcelain Division.

RUGG, ORMUND I., 107 Oak St., River Rouge, Mich.; chemical engineer, Ford Motor Co. Glass Plant.

SEEL, ELSIE A., Canandaigua, N. Y.

SIMPSON, THOMAS P., Socony-Vacuum Oil Co., Inc., Research & Development Lab., Paulsboro, N. J.

SORENSEN, VICTOR, 700 E. Maple St., Glendale 5, Calif.

TAFT, KATHLEEN I., 22 Maple St., Addison, N. Y.; laboratory technician, Corning Glass Works.

TRYON, WILLIAM P., 1971 East 119th St., Cleveland 6, Ohio; sales manager, Williston Fire Brick Co.

WOOD, LEWIS C., Braden Copper Co., Rancagua, Chile, South America; chemical and metallurgical engineer.

Student

New York State College of Ceramics: JANE P. HARTSOOK.

* Indicates former member of The Society rejoining.

MEMBERSHIP WORKERS' RECORD

CORPORATION: P. E. Cox 1, C. W. Given 1, F. A. Petersen 1, E. M. Sarraf 1, Office 1.

PERSONAL: L. S. Backus 1, W. C. Cress 1, W. E. Dornbach 1, T. H. Elmer 1, J. A. Foster 1, L. J. Frost 1, A. M. Hossenlopp 1, J. W. Iliff 1, Theodore Lenchner 1, J. M. Lucas 1, E. L. Maxson 3, R. Newcomb, Jr. 1, J. C. Richmond 1, R. Russell, Jr. 2, T. W. Shook 1, W. T. Smith 1, R. L. Stone 2, Office 5.

STUDENT: C. W. F. Jacobs 1.

GRAND TOTAL: 32.

ROSTER CHANGES IN NOVEMBER*

Personal

AUSTIN, JANET, Henry Phipps Psychiatric Clinic, Johns Hopkins Hospital, Baltimore 5, Md. (West Haven, Conn.)

BACON, J. L., 816 Race Ave., Lancaster, Pa. (Millville, N. J.)

COFFMAN, WILLIAM N., Keystone Abrasive Wheel Co., Gregg and Hammond Sts., Carnegie, Pa. (Ellwood City, Pa.)

CORBETT, PAUL M., Dept. of Ceramics, Pennsylvania State College, State College, Pa. (Philadelphia, Pa.)

DIXON, FRED W., JR., Cleveland Foundry Co., 2818 Harvard Ave., Cleveland, Ohio (Rockford, Ill.)

ECKERT, E. W., Westinghouse Electric & Mfg. Co., Construction Dept., Maloney Bldg., Pittsburgh, Pa. (Derry, Pa.)

EUBANK, WILLIAM R., Portland Cement Association, National Bureau of Standards, Washington, D. C. (Pittsburgh, Pa.)

FORD, JAMES W., 78 Chateau Terrace, Snyder, N. Y. (Buffalo, N. Y.)

FOSTER, JOHN A., Bergen Precision Castings, Inc., Pleasantville, N. Y. (Detroit, Mich.)

FULCHER, GORDON S., 68 Snake Hill Rd., Belmont, Mass. (Springfield, Vt.)

GALBREATH, WILLIAM W., JR., Box 551, Massachusetts Institute of Technology Dorms, Cambridge 39, Mass. (Norris, Tenn.)

GORNALL, HENRY A., 437 Third St., N. W., New Philadelphia, Ohio (Magnolia, Ohio)

HANSEN, J. E., Ferro Enamel Corp., 4150 East 56th St., Cleveland 5, Ohio (Bedford, Ohio)

HUTT, GORDON M., Development Dept., Room 703 Canadian Pacific Railway Co., Windsor Station, Montreal, Quebec, Canada (Winnipeg, Manitoba, Canada)

JACKSON, L. P., Mid-West Abrasive Co., Owosso, Mich. (Detroit, Mich.)

JACKSON, NELOM, Mayfield, Ky. (Paris, Tenn.)

JOHNSON, ENS. ARNOLD G., 923 11th St., N. E., Washington, D. C. (Rossford, Ohio)

KERR, CHARLES H., Hixson Cottages, Bradenton Beach, Fla. (Arlington, Va.)

KOCHER, DANIEL W., 2693 Hibbert Ave., Columbus, Ohio (Chicago, Ill.)

KRIEGEL, MAJOR WILLIAM W., Governors Island, N. Y. (Fort Bliss, Texas)

KURZ, WALTHER, 291 Market St., Newark 5, N. J. (Perth Amboy, N. J.)

KWATE, BERNARD, 1356 Sir Francis Drake Blvd., San Anselmo, Calif. (Pine Bluff, Ark.)

MORROW, C. T., 1800 Farmers Bank Bldg., Pittsburgh 22, Pa. (Cape May, N. J.)

REIMER, JOHN J., 5314 First St., N. W., Washington 11, D. C. (Alfred, N. Y.)

RICE, GEORGE A., 1601 Chrisler Ave., Schenectady 3, N. Y. (Cleveland, Ohio)

TURNBULL, JOHN E., 1101 Kemp Ave., Ironton, Ohio (Akron, Ohio)

WEIDMAN, V. WESLEY, 3105 W. Second St., Apt. B, Wilmington, Del. (Niagara Falls, N. Y.)

* Address in parentheses is former address.

Values Will Accrue to You

If You Participate in the 47th Annual Meeting,

Hotel Statler, Buffalo, N. Y.,
April 15–19, 1945

DOUBLE THE MEMBERSHIP

The slogan adopted by the Membership Committee and by our President is to "Double the Membership" of The Society, both Personal and Corporation. There would be no sense in this unless The Society were to expand its activities in the interest of ceramic arts, science, and technology.

The Society should have a research fund with a trust fund agreement and with a Board of Managing Directors of five or seven members, each serving for a period of five years and with rotation in office. The Society should have a full-time Technical Secretary who, under direction of the Research Board, would assist in securing technical and research programs, fellowships, and cooperative researches. The Society need not operate or supervise a laboratory but could with profit to all parties concerned exploit the research facilities of universities, institutes, bureaus, and surveys.

One Local Section Secretary advises that there are 200 men in his city who have the industrial grade of foreman or better who should be members of The American Ceramic Society. What can and what will the American Ceramic Society have to offer these 200 prospective members? The question is yours to answer.

Yours for Victory,

ROSS C. PURDY, *General Secretary*

President Fritz Indorses Endowment

The Industrial Publications, Inc., has published timely editorials in *Ceramic Industry* and in *Brick & Clay Record* urging the endowment of The American Ceramic Society with a substantial sum so that ceramic education and research may be more actively promoted.

The American Ceramic Society will be and will do what the American ceramists decide that it shall be and shall do. The Society is their instrument. Its need for financial support is simply the need as determined by American ceramists for promotional activities beyond that of the present program of meetings, committee activities, and publications.

The ceramists federated in The American Ceramic Society have achieved considerable in research and education, and are gathering funds for greater promotional achievements. They can and will do more. Here is a recital of some things they have done.

(1) Throughout the past forty-six years The Society has promoted ceramic education in schools, bureaus, and research institutes.

(2) The Society has so conserved its financial resources that it now has a cash reserve of $39,816.93 invested in Government bonds to protect the funds which have been gathered by different groups for specific purposes.

(3) In 1927–1929, the Glass Division collected and expended a research fund totaling $10,000. Of this there remains $500, credited and subject to disposal by the Glass Division.

(4) In 1943–1944, the Enamel Division collected $4026 with which to finance the publication of a Bibliography—the second one. The first Bibliography was published in 1929. They now have a cash reserve of $449.82 and a stock of books which is being sold.

(5) The Ceramic Educational Council of this Society has an endowment of $1000 given by the publishers of *Ceramic Industry* and the *Brick & Clay Record*. With this they will give awards to students presenting reports on ceramic researches.

(6) The Fellows of The Society have by individual contributions a fund which, of this date, has a residual totaling $1741.23.

(7) The Institute of Ceramic Engineers by member assessments has financed its activities and has accumulated a sum now totaling $2298.59.

(8) The Society received a cash endowment of $100 from the Industrial Publications, Inc.

The reserves for promotion of ceramic education and research in these six groups total $6089.64.

Each of the seven Divisions should have a substantial endowment for the promotion of the science and technology in its particular field.

The Institute of Ceramic Engineers, the Fellows, and the Ceramic Educational Council could profitably use substantial endowments.

The Society, by its accumulation of an invested reserve of nearly $40,000, shows its capacity to serve and to conserve.

The needs of The Society are the needs of ceramics in America. The Society could use and should have greater financial facilities for the promotion of ceramic investigations and for the gathering of technical information. The expansion of these services is needed because our membership is increasing rapidly due largely to the campaign to "Double the Membership."

The addition of a Technical Secretary to the staff of The Society, as recommended by Secretary Purdy, would be an excellent way to more effectively carry on this work, but this cannot be done without additional funds. The Industrial Publications' proposal which presents a plan to provide such funds, therefore, deserves serious consideration. If the American ceramists sincerely believe that the time has come for The Society to increase and expand the scope of its work, then the establishment of a trust fund can be made a distinct possibility.

The officers and Board of Trustees of The Society are ready to do whatever the American ceramists believe should be done. Your views and recommendations are wanted.

Very truly yours,

EDWIN H. FRITZ, *President*

SPECIFICATION BY WHICH TO MEASURE ONESELF

"Man Specification"

Assistant to Vice-President in Charge of Manufacturing

The Company

A moderate-sized company long established, ably managed, soundly financed, a leader in its industry.

The Position

Assistant to the vice-president in charge of manufacturing. The position calls for a well-rounded experience in the process type of production.

Education

Engineering college, graduate or equivalent. Preference for a man with a mechanical engineering training, plus courses in industrial engineering.

Personal

Age range: 35 to 45. High rating: Reliability, intelligence, constructive imagination, sound judgment, good health, and abundant energy. Must be emotionally stable and capable on occasion of working long hours under pressure.

General Abilities

Outstanding ability to take the lead in formulating policies and plans and interpreting these into appropriate action.

Must know how to organize and deputize, both in accordance with broad general principles and with consideration for the specific strong and weak points of available personnel.

Particularly able in anticipating and detecting manufacturing difficulties; keen in defining problems quickly; well versed on likely sources of helpful information; have the ability to arrive at practical decisions without delay or vacillation; know how to enlist full cooperation of all department heads, as well as maintain their respect and confidence.

Must possess the ability to negotiate with labor organizations, to handle grievance procedures, and to train plant superintendents and foremen in effective human relations. Must also set a good example himself in his relationships with subordinates, associates, and superiors.

Must be a "leader," not the "driver" type of administrator; maintain patience while developing subordinates who are seeking to improve; give credit to those who deserve it; invite confidence and enlist cooperation; build and maintain morale and company loyalty.

Work Experience

Experience should include at least five years in supervising manufacturing operations, construction and administrative activities in a continuous-process industry.

Must have had both staff and line responsibilities. While functioning in a line capacity, he should have demonstrated that he knows how to make good use of staff work as an aid to making his own efforts more effective.

Should have a good background in production planning and control, plant engineering, plant layout, materials handling, time and motion study, standards, job evaluation, rate setting, cost finding, and budgetary procedure.

Must know how to build manufacturing budgets and use them in maintaining effective control.

Appropriate Experience

Plant management and industrial engineering in a comparable manufacturing field.

Compensation

Open.

Frank Matthew Hartford

Mr. Hartford died October 24, 1944, in São Paulo, Brazil. For necrology notice see *Bull. Amer. Ceram. Soc.*, 23 [11] 445 (1944).

CHICAGO SECTION

The Chicago Section held a dinner meeting November 13, 1944, at the Electric Club in the Civic Opera Building, Chicago, Ill.

Joseph Manuele, director of quality control, Westinghouse Electric & Manufacturing Company, spoke on quality control in production.

Following the address, a movie on the Carlsbad Caverns and the Colorado Canyon was shown.

APPRECIATION OF SERVICES OF DEAN MAJOR E. HOLMES

Resolution Passed by Ceramic Association of New York

WHEREAS, The Ceramic Association of New York has now completed a decade of successful operations and accomplishment, and

WHEREAS, this Association was conceived and organized, and energized throughout these ten years by Dean Major E. Holmes, and further

Recognizing that without his guidance, his persistence, and his enthusiasm, neither this Association nor the Ceramic Experiment Station sponsored by our Association would have been founded; be it

Resolved, therefore, that this great debt to Doctor Major E. Holmes, Founder, Secretary, and Energizer of The Ceramic Association of New York, be hereby recognized and gratefully acknowledged by the Ceramic Industry of New York State through the Directors and members of our Association,

That their thanks be formally recorded in the Minutes,

And further, as a more tangible expression of our appreciation, we ask the Dean to accept a check for One Hundred Dollars, to be used at his discretion in connection with the work of the Ceramic College.

—For the Board, by S. F. WALTON, *President*

Alfred, N. Y.,
October 28, 1944

H. C. BEASLEY

H. C. Beasley, porcelain enameling superintendent of the Co-Operative Enameling Co., Cleveland, Ohio, died suddenly of a heart attack September 27, 1944. Mr. Beasley died while at work, as he was passing through the plant. He was fifty-five years of age.

Mr. Beasley was a highly successful porcelain enamel plant operator who had contributed substantially to America's supply of war equipment in the present emergency. He joined the Co-Operative Enameling Company seven years ago and helped design and develop the plant. When the war began, he converted furnaces and equipment to heat-treating and installed additional furnaces for the work. A large volume of production had been turned out for the Cleveland Ordnance District.

He had previously been associated with the Ferro Enamel Corp., Cleveland, Ohio; the Baltimore Enamel & Novelty Co., Baltimore, Md.; Servel, Inc., Evansville, Ind.; and the Coonley Mfg. Co., Cicero, Ill.

Together with R. MacDougall, Mr. Beasley had successfully designed one of the first continuous porcelain enameling furnaces. Called the Be-Mack Furnace, it was a forerunner of modern-day continuous porcelain enameling furnaces.

Mr. Beasley, a member of The American Ceramic Society, is survived by his widow, Anna Beasley, and one son, H. C. Beasley, Jr., Lt. (s.g.), USNR.

CERAMIC ASSOCIATION OF NEW YORK

REPORT OF ELEVENTH ANNUAL MEETING

The tenth anniversary meeting of the Ceramic Association of New York was held at the New York State College of Ceramics, Alfred, N. Y., October 28.

The meeting was opened by J. N. Norwood, President of Alfred University. He spoke on the history of the institution and the important expansion program for the Ceramic College after the war.

S. F. Walton of the Exolon Co., Tonawanda, N. Y., President of the Association, presided. Mr. Walton delivered an address on the accomplishments of the Association during the ten years of its existence (see p. 489, this issue). The Association was organized in 1933 by Dean M. E. Holmes. It has had a steady growth since that date and now has the largest membership in its history. During these years, a large number of very important developments for the industry and for the New York State College of Ceramics have been achieved. The Association sponsored a program of silicosis prevention. Its activities made possible the establishment of the Ceramic Experiment Station of the New York State College of Ceramics. Bulletins on the research facilities of the College were published. This and other activities have resulted in an income to the College this year of $30,000 for research fellowships. Prizes for senior student theses have greatly stimulated research on the part of the students. The support the Association gave the College enabled it to obtain from the legislature a special salary law that gives the College an exceptionally high salary scale. An expansion and postwar building program has been provided which will more than double the facilities of the College. These are some of the highlights of the Association accomplishments.

Mr. Walton then introduced to the audience J. C. Hostetter, Clarence Austin, and Edward Schramm. These are members of the original Board of Directors who were present at the meeting.

Then followed a citation in the form of a resolution by the Board of Directors honoring Dean M. E. Holmes and thanking him for organizing the Association and energizing it through the ten years of its existence (see p. 487, this issue). This resolution, accompanied by a check for $100, was unanimously approved by the Association.

Technical Program

The remainder of the morning's program was devoted to a report on the research work which the Ceramic College has been doing the past year. This portion of the program was presented by C. R. Amberg and J. F. McMahon by means of charts, slides, exhibits, and demonstrations. The following is a brief summary of the subjects presented.

An ambitious program of collecting and extensive testing of all the clays and shales of New York State is well under way with 319 samples collected to date. The State Departments of Geology, Commerce, and Education are actively cooperating in this project, and the testing is being done by the Research Department of the New York State College. Other than ordinary brick clays and shales, some clays with interesting bloating characteristics, with slip clay properties, and with self-glazing properties have been uncovered.

The raw and firing characteristics of wollastonite were dealt with. The fibrous character of the ground material was brought out and samples involving its use in the manufacture of insulation blocks and pellets were shown. Its fired properties alone and mixed with TiO_2, ZrO_2, and SiO_2 were discussed; it is similar to talc in firing behavior and very hard bodies can be made with it in combination with TiO_2 and ZrO_2.

The firing properties of New York State diopside were tested in similar fashion with similar results. It also gave promise as a substitute for talc in wall-tile bodies.

The correlation of the laboratory freezing test with natural-exposure failures of brick was discussed. Good correlation between the two types of testing was found for brick of similar absorptions. With brick of similar saturation coefficients, the correlation was good for stiff-mud shale brick and rather poor for soft-mud clay brick; the clay brick showed up far better under natural exposure than in the laboratory freezing test.

Clay treated in a colloid mill was found to have reduced particle size but in the case of the plastic ball clay or stoneware clay the apparent particle-size reduction was due almost entirely to the breaking up of flocculated aggregates. Deflocculated, these clays had little difference in particle size as a result of colloid milling.

The effects of five iron-bearing minerals on the disintegration of firebrick in carbon monoxide were discussed. Other factors such as the particle size of the iron minerals, the temperature, and atmosphere of firing were studied. That the black material causing disintegration was of a magnetic nature and contained only traces of carbon was an interesting fact brought out.

In whiteware, the improvement in impact resistance that is possible by means of change in glaze composition or by means of engobes was discussed as well as the benefits in glaze properties that can be obtained by the use of strontium carbonate.

At the afternoon session, Mr. McGrath from the New York State Department of Commerce outlined the work of his Department and the ways in which it is now serving industry. Charles S. Pearce, Associate Secretary of The American Ceramic Society, delivered an informative address on the subject "Trade Associations." General Secretary Ross C. Purdy, in introducing Mr. Pearce, also gave a brief talk on "The American Ceramic Society, Its Functions and Policies."

A great deal of interest was excited by the display and discussion of plans for a permanent exhibit of New York State ceramic products. A committee of the State Association has initiated at Alfred a contest for the best design for such an exhibit. The junior and senior students of the Ceramic Design Department had designs in an advanced stage of completion for this project. It is hoped that one of these will eventually be set up as a permanent display of New York ceramic products in one of the State buildings in Albany.

Business Meeting

At the business meeting, the new members of the Board of Directors were elected as follows:

G. J. Easter, Carborundum Co., Niagara Falls, N. Y., *President;* G. D. Phillips, Olean Tile Co., Olean, N. Y., *Vice-President;* M. E. Holmes, New York State College of Ceramics, Alfred, N. Y., *Secretary-Treasurer;* S. F. Walton, Exolon Co., Tonawanda, N. Y.; L. E. Barringer, General Electric Co., Schenectady, N. Y.; G. S. Diamond, Electro Refractories & Alloys Corp., Buffalo, N. Y.; E. W. Schramm, Onondaga Pottery Co., Syracuse, N. Y.; J. C. Hostetter, Mississippi Glass Co., St. Louis, Mo.; J. L. Jova, Jova Brick Works, Roseton, N. Y.; Clarence Austin, Binghamton Brick Co., Inc., Binghamton, N. Y.; P. C. Olsen, Federal Seaboard Terra Cotta Corp., Perth Amboy, N. J.; W. J. Degenhart, John H. Black Co., Buffalo, N. Y.; W. W. Oakley, Corning Glass Works, Corning, N. Y.; R. E. Daniels, Federal Portland Cement Co., Buffalo, N. Y.; Whitney Walrath, Acme Shale Brick Co., Buffalo, N. Y.; Grover W. Lapp, Lapp Insulator Co., Inc., Le Roy, N. Y.; and O. I. Chormann, Pfaudler Co., Rochester, N. Y.

TENTH ANNIVERSARY CERAMIC ASSOCIATION OF NEW YORK PRESIDENT'S ADDRESS

By S. F. Walton

I. Introduction

The Ceramic Association of New York is officially ten years old this year. Ten years ago last spring the Constitution was formally adopted and the name was changed from the New York Ceramic Industries Association to the present, more euphonious title.

It is fitting at the end of this decade for us to review the progress that has been made in the past decade. What was the object or goal of our founders? Have we hewed to the line? What have we accomplished? How much remains to be done?

II. Concept

The original concept of our Association grew out of a meeting of minds of two men, H. H. Turner, Assistant Commissioner of Higher Education, and Dean M. E. Holmes. It was their decision that there was need for more effective working contact between the ceramic industries of the State and the State College of Ceramics. The reaction of the various industries to this concept was so favorable that our Association became an active organization representing the ceramic industries of the State.

(1) Constitution

The Association has, I believe, met the ideas of the founders as set forth in the Constitution. Briefly stated, these objects were the development of the ceramic industries of the State and the promotion of public interest in the ceramic raw materials and ceramic products of the State through research founded at the State College, and cooperation with the State College in the improvement of ceramic education in art, technology, and ceramic engineering; cooperation of the ceramic industries in all matters of common interest, and the advancement and diffusion of ceramic knowledge.

III. Accomplishments

Let us discuss our accomplishments and see how we have hewed to the line.

Our membership has nearly doubled, with a present membership of more than one hundred, representing practically every ceramic industry in the State.

In promoting research and development work, our Association was primarily responsible for the appropriation of funds for the establishment of the Ceramic Experiment Station at the College eight years ago.

In seeing that the funds necessary for its continued maintenance and support are included in the budget each year.

And in supporting increased amounts in the budget.

The annual report of the Ceramic Experiment Station and the publishing of the monthly bulletin by our Association carry out our promise of disseminating ceramic knowledge.

Continuing along the line of research, our Association has been helpful in the establishment of research fellowships at the College by publishing an interesting pamphlet on "Industrial Fellowships at the New York State College of Ceramics." Today $30,000 is contributed for this purpose and more would be available if the personnel were to be had.

Our Association established a thesis prize to increase interest in research by undergraduates. This prize and the recognition it brings are sought by the student as a foremost honor on graduation.

Our Association has actively backed the Board of Managers in making the necessary changes over the years to provide for the New York State College of Ceramics a breadth and scope lacking ten years ago. Ten or eleven years ago this institution was classed as a School of Ceramics and specialized in pottery and art. Today it ranks as a College. Though recognized still as a leading institution of its kind in the study of ceramic art, pottery, and design, it is essentially and primarily today an Institute of Technology and Ceramic Engineering. Here is established the first full four-year course in glass technology in the United States. The Department of General Ceramic Technology and Engineering has been increased in importance.

When the new building program, in which we have taken special interest, is finished at an expenditure of more than $300,000, no institution anywhere will excel it. It will be the finest plant of any institution of like technology in the world.

Our Association was helpful in aiding the passage in 1942 of the Salary Classification Bill. This Bill makes it possible to pay professors and instructors of the College on a scale equal to any school in the country and compete with other schools as well as with industry for qualified men. This salary change was made in spite of the low enrollment caused by the war.

IV. Additional Achievements

We have sponsored other work than matters strictly attached to the College or the Experiment Station.

A study of the silicosis hazard in our industry was a first consideration.

A Directory of the Ceramic Industries of New York was published in 1936, a creditable piece of work.

Our Association has sponsored and expects to publish a series of three monographs. The first monograph is entitled "Ceramic Microscopy as a Research Tool in the Investigation of Ceramic Materials." It is in the process of being edited.

Our Association for the past year has sponsored a display exhibit to be located in Albany. Since college opened, students of design and others have been working on plans and designs for this display, competing for a series of prizes offered by the Association.

V. The Record

This is a record of progress of a decade. It could not have been accomplished without the unstinting help of the men who participated in the formation of the Association and who have actively supported it ever since. It is fitting we honor these men here today.

As I call the roll will these gentlemen please stand: J. L. Jova, our first president, Clarence Austin, J. C. Hostetter, O. I. Chormann, and E. W. Schramm.

These men were among our first Board of Directors and are, in the order named, successive presidents and are still members of the Board.

I must also mention Major J. K. McNeely, our sixth president, who, owing to active work for Uncle Sam in the armed service, could not be present. He has most ably presented our case and the needs of the College to the powers that be at Albany.

I wish also to present Grant S. Diamond, our seventh president. (Will he please stand?) His activities have been so recent I do not need to specify them.

No association can ever be successful without one individual who through the years is the spark plug. Our spark plug is our Permanent Secretary, Dean M. E. Holmes. (Will he please stand?) It is fitting that we pay him special honor.

All our members can be justly proud of our Association and these men who have been its mainstay.

We can be more than proud of this State College here at Alfred as it is today and as it will be in the future.

Do you gentlemen know or realize that the New York State College of Ceramics is the only State-supported college in the State of New York giving a four-year course in engineering? The only engineering institution in the State where the tuition is free? The New York State College of Ceramics is a College of the University of the State of New York and it ranks with the College of Forestry at Syracuse and the College of Agriculture at Cornell.

VI. The Forecast

Ten years ago the founders of this Association looked ahead ten years or more. I wonder if our attainments have met with their approval.

Let us also look ahead and set our course for the next ten years.

First, a membership that includes every active ceramic industry in the State is a *must* consideration.

Second, an augmented Ceramic Experiment Station with a larger active staff.

Third, the establishment of a larger group of fellows.

Fourth, a larger State College with an increased staff and student enrollment to utilize the new facilities to the full, needing and getting the cooperation of our Association.

I cannot, however, close this address without mentioning one problem which needs the attention of the new Board and officers to be elected this afternoon and the active participation of all the members of the Association. This is the problem of the re-employment of ceramic engineers and technicians in the postwar period. There will be two types, those who were employed and those who were taken from college before completion of their course or were just allowed to finish. It is this second group, those who have no plant experience, which will be the greater problem. We must make these men want to come back to our industries and continue their profession.

VII. Conclusion

I wish to thank the members of the Board and the members of this Association for their cooperation in the year I have been president and in making the past year an interesting experience.

47th ANNUAL MEETING
The American Ceramic Society, Inc.
Buffalo, N. Y., April 15–19, inclusive, 1945

THE ENAMEL BIBLIOGRAPHY

In the recently published Enamel Bibliography the information on the title page is misleading. The list was not compiled by E. H. McClelland. Morris Schrero was in responsible charge of the entire work.

In outlining the scope of the list and establishing the boundaries of the field to be covered, valuable advice was given by J. E. Rosenberg, Chairman of the Bibliography Committee of the Enamel Division of The American Ceramic Society.

Various members of the Technology Department staff gave some help with the list, but the work was entirely in the hands of Mr. Schrero, who planned the compilation, supervised the strictly routine operations, and did much of the work.

Considerable routine work, such as clipping and pasting, was done (under supervision) by clerical help provided by the United States Works Progress Administration and the United States Work Projects Administration.

The index was made in the office of *Ceramic Abstracts*.

The work of compilation was undertaken by the Technology Department of the Carnegie Library of Pittsburgh at the request of the Bibliography Committee of the Enamel Division and Mr. Schrero's connection therewith was well known, his competent work having been recognized by an honorarium from The American Ceramic Society in 1941 (see *Bull. Amer. Ceram. Soc.*, **20** [8] 291 (1941)) at the suggestion of the Bibliography Committee.

REPORT OF GLASS DIVISION RESEARCH COMMITTEE

The Research Committee of the Glass Division met September 13, 1944, at the University of Pittsburgh, Pittsburgh, Pa. Those in attendance were Alexander Silverman, *Chairman*, C. E. Leberknight, and K. C. Lyon (ex-officio member of the Committee). O. G. Burch, the third member of the Committee, was unable to attend.

The results of their deliberations follow:

(1) It seems desirable that physical properties and constants of important ceramic materials for which these values have not been established should be determined. Further, that a recommendation to this effect should be made to Government bureaus, to schools and departments of ceramics, and to science departments of colleges and universities.

(2) It seems undesirable to suggest research problems pertaining to any particular branch of the glass industry, as these would be cared for either by the industries or by foundations that have been established.

(3) In the event that existing foundations do not adequately serve the glass industry as a whole, it might seem desirable to suggest the establishment of a general foundation or institution with broad interests.

Respectfully submitted,
ALEXANDER SILVERMAN, *Chairman*,
Research Committee

SOUTHERN CALIFORNIA SECTION

A meeting of the Southern California Section of The American Ceramic Society was held October 25, 1944, at the Baux Restaurant, Los Angeles, Calif. Our attendance was seventy-six.

The following program was presented:

(1) "Potentialities of Beneficiating Ceramic Raw Materials" by W. F. DIETRICH, Dietrich, Morse and Associates, Claremont, Calif.

(2) "Refractories" by GEORGE FERDINAND, Kaiser Co., Inc., Iron and Steel Div., Fontana, Calif.

The next meeting of the Section will be held December 22.

—GUY WURTSBAUGH, *Secretary*

NORTHERN OHIO SECTION GETS OFF TO FINE START

A steady, cold rain driven by strong gusts of wind failed to dampen the enthusiasm of a large turnout of ceramists at the initial meeting of the Northern Ohio Section of The American Ceramic Society October 10 at the Cleveland Engineering Society building. After an informal get-acquainted period in the comfortable C. E. S. lounge, the group gathered in the dining room where forty-one persons sat down to an excellent dinner, at which the guests of honor were President E. H. Fritz and General Secretary Ross C. Purdy.

By the time the meeting was formally called to order at 8:00 P.M., additional arrivals from out of town increased the attendance to approximately sixty persons. In addition to the members from the Cleveland area, the registration lists showed delegations were present from Akron, Canton, Cuyahoga Falls, Elyria, and Fremont, Ohio. Several congratulatory messages were read from members who were unable to be present, promising future support.

During the brief business meeting, Edward M. Sarraf of the Harbison-Walker Refractories Co., Cleveland, Ohio, was elected Chairman and Stephen M. Swain of the North American Refractories Co., Cleveland, Ohio, was elected Secretary.

President Fritz presents Northern Ohio Section charter to Chairman Sarraf. (Photo taken by M. J. Bozsin.)

President Fritz, acting for The Society, presented to Chairman Sarraf the Charter for the new Section, inscribed with the names of the following petitioners, most of whom were present, who assisted with its organization: Ralph M. Bowman, Republic Steel Corp., Cleveland, Ohio; Edward E. Callinan, Timken Roller Bearing Co., Canton, Ohio; Herbert D. Carter, Harshaw Chemical Co., Cleveland, Ohio; Russell G. Greeves, Kelley Island Lime & Transport Co., Cleveland, Ohio; J. Edward Hansen, Ferro Enamel Corp., Cleveland, Ohio; Burnham W. King, Jr., Harshaw Chemical Co., Cleveland, Ohio; Gerald E. Reinker, General Electric Co., Cleveland, Ohio; Edward M. Sarraf, Harbison-Walker Refractories Co., Cleveland, Ohio; Stephen M. Swain, North American Refractories Co., Cleveland, Ohio; Benjamin J. Sweo, Ferro Enamel Corp., Cleveland, Ohio; and Albert S. Walden, National Carbon Co., Cleveland, Ohio.

President Fritz also spoke of his current goal to "double the membership" of The Society, pointing out that active, thriving Local Sections provide an excellent source of potential new members for the national Society, especially among younger ceramists who might not ordinarily be able to attend the annual national Meetings.

Dr. Purdy spoke on "Why a Local Section in Northern Ohio," welcoming the group as the eleventh Local Section and mentioning that new Sections are also being organized in Toledo and Cincinnati, which, with the present Section in Columbus, demonstrate the active interest in The Society throughout the State of Ohio.

The main address was given by Elmer L. Lindseth on "Cleveland Post-War." Mr. Lindseth is vice-president of the Cleveland Electric Illuminating Company and chairman of the Cleveland Committee on Economic Development and interestingly described the expected industrial growth of this area after V-day.

The meeting was concluded with a sound motion picture, "See Cuyahoga First," showing in natural color the beauty of the four seasons in the attractive chain of metropolitan parks surrounding Cleveland in Cuyahoga County.

The Section has affiliated with the Cleveland Technical Societies Council, composed of local chapters of thirty-three active engineering and scientific societies, and each member is receiving its weekly magazine, *Cleveland Engineering*.

ST. LOUIS SECTION

The St. Louis Section held a dinner meeting at the Forest Park Hotel, St. Louis, Mo., November 8, 1944.

Following a business meeting, C. T. Cardwell, District Representative of the Training Within Industry Service of the War Manpower Commission, discussed the Training Within Industry Program which has been evolved as an important aid of war production for the increase, both quantity and quality, of output. Although the services of TWI are offered at present to war industries only, it undoubtedly has sufficient merit to be a valuable tool in peacetime and we all should have some understanding of how it works.

The next meeting of the Section will be held January 10, 1945.

—H. H. HANNA, *Chairman*

CENTRAL OHIO SECTION

The Central Ohio Section held a dinner meeting December 8, 1944, at the Southern Hotel, Columbus, Ohio.

The following program was presented:

(1) "A Verbal Trip Through the Royal Danish Porcelain Factory (Royal Copenhagen)" by ERIC HELLMAN, a graduate of the Department of Ceramics, University of Copenhagen, Copenhagen, Denmark, now with the Battelle Memorial Institute, Columbus, Ohio.

(2) "Steatite Porcelain" by E. H. FRITZ, Stupakoff Ceramic & Mfg. Co., Latrobe, Pa., and President, The American Ceramic Society.

(3) "American Fine China" by Ross C. PURDY, General Secretary, The American Ceramic Society, Columbus, Ohio. Dr. Purdy augmented his talk with a display of American chinaware.

Results of the election of officers held at this meeting will be announced in a later issue of *The Bulletin*.

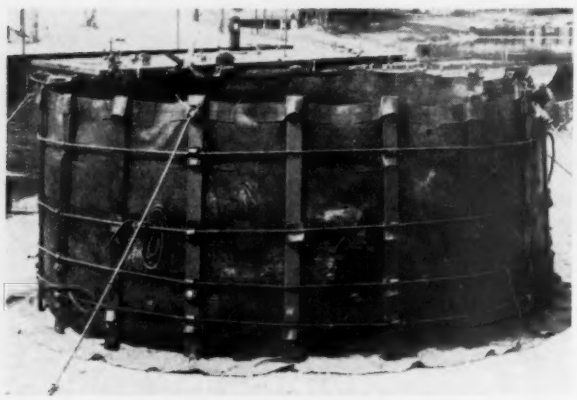
NORTHWESTERN OHIO SECTION

President E. H. Fritz presented this new Section in Toledo, Ohio, with an illuminated charter on November 30, 1944, before one hundred and twenty-five enthusiastic dinner attendants.

F. W. Preston was the guest speaker. He spoke on the subject "A New Structural Material: Glass-Plastic Combinations."

GLASS FABRIC WATER-STORAGE TANK DEVELOPED FOR ARMED FORCES

To provide combat troops in the Pacific with an adequate supply of pure drinking water, a new type of water-storage tank made of glass fabric coated with synthetic rubber has been developed by the United States Rubber Company working closely with the Army Corps of Engineers and is now in production in four of the Company's



Glass fabric water-storage tank. (Official U. S. Army Corps of Engineers photo.)

plants. The tank is not affected by rot or mildew, resists fungus growth, is lightweight, extremely strong and durable, and completely watertight. As it is collapsible and can be compactly folded, it is easy to transport and set up in the field. Fifty-four inches high and more than 11 feet in diameter, it will hold 3000 gallons of water.

A.S.T.M. ADVANCES PUBLICATION OF BOOK OF STANDARDS

Heavy demands for the 1942 Book of A.S.T.M. Standards and its Supplements occasioned by the war-production efforts have necessitated advancing by a full year publication of the next book. Normally this would come out in November–December, 1945, on the triennial basis, but the book will be issued in December, 1944.

Widely used by American industry and many branches of state and federal governments, this book, providing authoritative specifications and tests for a wide range of engineering materials, will cover about 6000 pages in three parts: I, Metals; II, Nonmetallic Materials—Constructional (cement, lime, concrete, paint, etc.); III, Nonmetallic Materials—General (petroleum, textiles, plastics, coal, rubber, etc.).

PHASE DIFFERENCE MICROSCOPY

A new increase in visibility through the microscope was demonstrated at the annual meeting of the American Association for the Advancement of Science held in Cleveland, Ohio, September 11–16. The report was made by A. H. Bennett, Director of Research, and O. W. Richards, Research Biologist, of the Spencer Lens Company, Scientific Instrument Division of the American Optical Company.

The method of obtaining the increased visibility was described some years ago, but equipment to make it practical has just been devised by men in the Research Division of the Spencer Lens Company. The Spencer contribution extends the method to the general case, the discovery that absorption may be as important as or more so than retardation, the preparation and use of a wide range of phase disks of both positive and negative types, and improved methods for coating the thin films in the manufacture of the phase plates.

Improvement in the visibility of many transparent materials and organisms is claimed. Many living cells, tissues, microorganisms, and industrial materials are so transparent that nothing can be seen when they are observed with the regular equipment. Owing to the fact, however, that their internal structures usually do have differences in refractive index, these differences can be changed from phase differences to intensity differences. This is done by illuminating the specimen with a hollow cone of light and using a retardation plate within the objective. They can be observed or photographed in the usual manner.

The method is called Phase Difference Microscopy.

SEMICENTENNIAL OF UNITED STATES-CANADIAN ELECTROCHEMICAL INDUSTRY

Electrochemists held their eighty-sixth convention at Niagara-Buffalo October 12 to 14, 1944, in recognition of the fiftieth anniversary of the North American electrochemical industry. Many products, commercially new or nonexistent fifty years ago, such as silicon carbide, chlorine, aluminum, phosphorus, Acheson graphite, artificial emery, and numerous high-melting ferroalloys, were first produced on a large scale with the aid of Niagara's bountiful hydroelectric power. These and other electrochemical products are of prime importance in the present conquest of Japan and Germany. Without them modern warfare would be impossible.

A gala event of the convention was the bestowal of the Acheson Gold Medal and One Thousand Dollar Prize on William Blum of the National Bureau of Standards in recognition of his outstanding services in the standardization of the electroplating art. Sidney D. Kirkpatrick, editor of *Chemical & Metallurgical Engineering* and president of the Electrochemical Society, made the formal presentation.

Past recipients of the Acheson award are Edward G. Acheson (graphite and silicon carbide), Edwin F. Northrup (induction furnaces), Colin G. Fink (tungsten, chromium, tin), Frank J. Tone (silicon and silicon carbide), Frederick M. Becket (ferroalloys), Francis C. Frary (aluminum), and Charles F. Burgess (electrolytic iron, dry batteries).

CANADIAN CERAMIC SOCIETY

The autumn dinner meeting of the Canadian Ceramic Society was held November 27, 1944, at the Engineers' Club, Toronto, Ontario, Canada.

J. R. Boyle, Canadian General Electric Co., Ltd., Toronto, spoke on "Electronics in Industry." He discussed the present and proposed industrial uses of electronic control equipment and augmented his lecture with sound films, lantern slides, and demonstrations.

AMERICAN FOUNDRYMEN'S ASSOCIATION

The 1945 Foundry Congress, the forty-ninth annual meeting of the American Foundrymen's Association, will be held in Detroit, Mich., the week of April 30–May 4. The event has been announced as the Fourth War Production Foundry Congress and the program is being planned to stress the necessity of continued high production by the foundry industry.

YOUR PERSONAL SOCIETY

The American Ceramic Society is of, for, and by ceramic persons and corporations. For forty-six years, their sole purpose has been promoting cooperatively their ceramic welfare.

By educational and research facilities promoted by them, ceramics in America has forged to leadership.

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Year	Meeting Place	President Elect	Vice-President Elect
1899	Columbus, Ohio	H. A. Wheeler (general)	Ernest Mayer
1900	Detroit, Mich.	Karl Langenbeck (general)	C. F. Binns
1901	Old Point Comfort, Va.	C. F. Binns (art)	Ernest Mayer
1902	Cleveland, Ohio	Ernest Mayer (whiteware)	F. W. Walker, Sr.
1903	Boston, Mass.	E. C. Stover (whiteware)	Heinrich Ries
1904	Cincinnati, Ohio	F. W. Walker, Sr. (whiteware)	A. V. Bleininger
1905	Birmingham, Ala.	W. D. Gates (terra cotta)	Ellis Lovejoy
1906	Philadelphia, Pa.	W. D. Richardson (structural clay)	Samuel Geijsbeek
1907	St. Louis, Mo.	S. G. Burt (art)	R. C. Purdy
1908	Columbus, Ohio	A. V. Bleininger (whiteware)	Charles Weelans
1909	Rochester, N. Y.	R. C. Purdy (general)	A. S. Watts
1910	Pittsburgh, Pa.	Heinrich Ries (general)	R. R. Hice
1911	Trenton, N. J.	Charles Weelans (whiteware)	L. E. Barringer
1912	Chicago, Ill.	A. S. Watts (general)	C. W. Parmelee
1913	Washington, D. C.	Ellis Lovejoy (structural clay)	A. F. Hottinger
1914	Wheeling, W. Va.	C. W. Parmelee (general)	D. T. Farnham
1915	Detroit, Mich.	R. R. Hice (structural clay)	R. T. Stull
1916	Cleveland, Ohio	L. E. Barringer (whiteware)	F. K. Pence
1917	New York, N. Y.	G. H. Brown (general)	C. E. Jackson
1918	Indianapolis, Ind.	H. F. Staley (enamel)	A. F. Greaves-Walker
1919	Pittsburgh, Pa.	R. T. Stull (structural clay)	R. H. Minton
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1928	Atlantic City, N. J.	M. C. Booze (refractories)	R. R. Danielson
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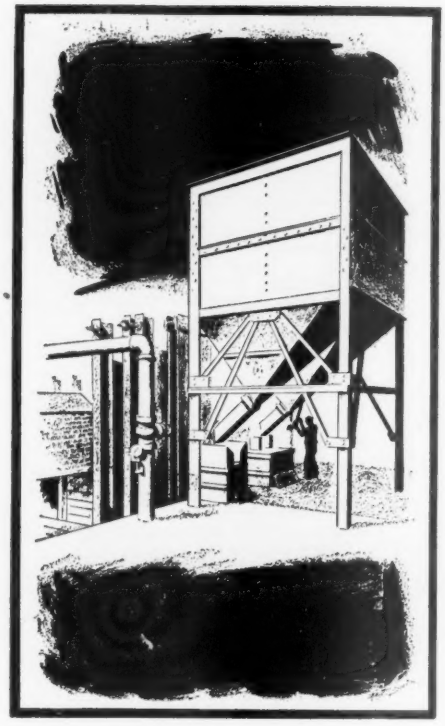
For Vice-President: J. EDWARD HANSEN, Ferro Enamel Corp., 4150 East 56th St., Cleveland 5, Ohio.
For Treasurer: JOHN D. SULLIVAN, Battelle Memorial Institute, Columbus 1, Ohio.

Any twenty-five members may act as a Nominating Committee to place their candidate in nomination for the offices of President, Vice-President, and Treasurer.



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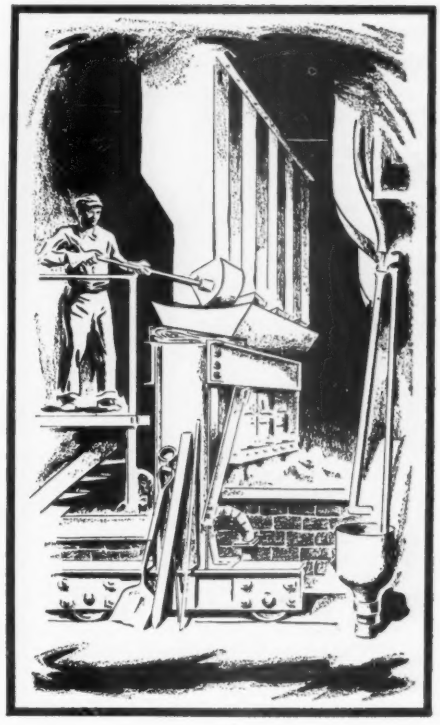

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Vitro Mfg. Co.

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Harshaw Chemical Co.
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Caustic Soda
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Hommel, O., Co., Inc.
Pennsylvania Salt Mfg. Co.
Stauffer Chemical Co.
Vitro Mfg. Co.

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Norton Co.
Pennsylvania Salt Mfg. Co.
Remmey, Richard C., Son Co.

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Du Pont de Nemours, E. I., & Co., Inc., Electrochemicals Dept.
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Harshaw Chemical Co.
Hommel, O., Co., Inc.
Metal & Thermit Corp.
Pemco Corp.
Pennsylvania Salt Mfg. Co.
Titanium Alloy & Mfg. Co.
Vitro Mfg. Co.

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Hommel, O., Co., Inc.

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Hommel, O., Co., Inc.

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Du Pont de Nemours, E. I., & Co., Inc., Electrochemicals Dept.
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Harshaw Chemical Co.
Hommel, O., Co., Inc.
Pemco Corp.
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Du Pont de Nemours, E. I., & Co., Inc., Electrochemicals Dept.
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Hommel, O., Co., Inc.
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Maxson, Elwyn L.
Potters Supply Co.
Spinks, H. C., Clay Co.
Vitro Mfg. Co.

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Foote Mineral Co.
Great Lakes Foundry Sand Co.
Hommel, O., Co., Inc.

Clay (Block)
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Clay (China)
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Harshaw Chemical Co.
Hommel, O., Co., Inc.
Maxson, Elwyn L.
Vitro Mfg. Co.

Clay—Cleaners, Feeders
Lancaster Iron Works, Inc.

Clay (Electrical Porcelain)
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Hommel, O., Co., Inc.
Maxson, Elwyn L.
Spinks, H. C., Clay Co.

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Harshaw Chemical Co.
Hommel, O., Co., Inc.
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Harshaw Chemical Co.
Hommel, O., Co., Inc.
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Vitro Mfg. Co.

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Ferro Enamel Corp.
Harshaw Chemical Co.
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Harshaw Chemical Co.
Hommel, O., Co., Inc.
Pemco Corp.
Vitro Mfg. Co.

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Du Pont de Nemours, E. I., & Co., Inc., Electrochemicals Dept.
Ferro Enamel Corp.
Hommel, O., Co., Inc.

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Harrop Ceramic Service Co.
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Harshaw Chemical Co.
Hommel, O., Co., Inc.
Pemco Corp.
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Vitro Mfg. Co.

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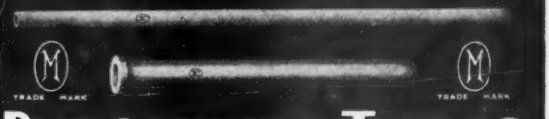

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★ MULLITE

★ REFRACTORY PORCELAIN

MONTGOMERY PORCELAIN PRODUCTS CO.
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Locust Bean—Powdered
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Norton Co. (*Crystolon*)
Remmey, Richard C., Son Co.

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Norton Co.
Remmey, Richard C., Son Co.

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Ilmenite
Orefraction, Inc.

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Iron (Enameling)
American Rolling Mill Co.

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Du Pont de Nemours, E. I., & Co., Inc., Electrochemicals Dept.
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Harshaw Chemical Co.
Hommel, O., Co., Inc.
Pemco Corp.
Vitro Mfg. Co.

Kaolin
Hammill & Gillespie, Inc.
Harshaw Chemical Co.
Hommel, O., Co., Inc.
Maxson, Elwyn L.
Vitro Mfg. Co.

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Carborundum Co.
Electro Refractories & Alloys Corp.
Ferro Enamel Corp.—Ceramic Supply Div.
Remmey, Richard C., Son Co.

Kilns, China (Decorating)
Drakenfeld, B. F., & Co., Inc.
Ferro Enamel Corp.—Allied Engineering Div.
Frazier-Simplex, Inc.
Harrop Ceramic Service Co.
Hommel, O., Co., Inc.
Swindell-Dressler Corp.

Kilns (Electric, Circular, Tunnel)
Ferro Enamel Corp.—Allied Engineering Div.
Harrop Ceramic Service Co.
Swindell-Dressler Corp.

Kilns (Laboratory)
Remmey, Richard C., Son Co.

Kryolith (see Cryolite)
Pennsylvania Salt Mfg. Co.

Laboratory Ware
Norton Co.

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Electro Refractories & Alloys Corp.

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Swindell-Dressler Corp.

Lehrs (Electric or Fuel Heated)
Frazier-Simplex, Inc.
Swindell-Dressler Corp.

Lehr Loaders
Frazier-Simplex, Inc.

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Corhart Refractories Co.
Electro Refractories & Alloys Corp.
Norton Co.
Remmey, Richard C., Son Co.
Vitro Mfg. Co.

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Foote Mineral Co.
Hommel, O., Co., Inc.

Lithium Minerals
Foote Mineral Co.

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Electro Refractories & Alloys Corp.
Norton Co.

Magnesia (Sintered, Calcined)
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Du Pont de Nemours, E. I., & Co., Inc., Electrochemicals Dept.
Harshaw Chemical Co.
Hommel, O., Co., Inc.
Pemco Corp.

Magnesite
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Du Pont de Nemours, E. I., & Co., Inc., Electrochemicals Dept.
Foote Mineral Co.
Hammill & Gillespie, Inc.
Harshaw Chemical Co.
Hommel, O., Co., Inc.
Vitro Mfg. Co.

Magnesite Calcined
Foote Mineral Co.
Hommel, O., Co., Inc.

Magnesium Carbonate
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Ferro Enamel Corp.
Harshaw Chemical Co.
Hommel, O., Co., Inc.

Manganese
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Du Pont de Nemours, E. I., & Co., Inc., Electrochemicals Dept.
Ferro Enamel Corp.
Hammill & Gillespie, Inc.
Harshaw Chemical Co.
Hommel, O., Co., Inc.
Vitro Mfg. Co.

Manganese Dioxide
Drakenfeld, B. F., & Co.
Ferro Enamel Corp.
Foote Mineral Co.
Hommel, O., Co., Inc.

Manganese (Oxide)
Corhart Refractories Co.
Drakenfeld, B. F., & Co., Inc.
Du Pont de Nemours, E. I., & Co., Inc., Electrochemicals Dept.
Ferro Enamel Corp.
Harshaw Chemical Co.
Hommel, O., Co., Inc.

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Hommel, O., Co., Inc.

Metals (Porcelain Enameling)
American Rolling Mill Co.

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Pemco Corp.

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Bausch & Lomb Optical Co.
Spencer Lens Co.

Microscopes (Stereoscopic)
Bausch & Lomb Optical Co.
Spencer Lens Co.

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Foote Mineral Co.
Hammill & Gillespie, Inc.
Harshaw Chemical Co.
Hommel, O., Co., Inc.
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Lancaster Iron Works, Inc.

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Norton Co.
Remmey, Richard C., Son Co.

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Harshaw Chemical Co.
Hommel, O., Co., Inc.

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Hommel, O., Co., Inc.
Vitro Mfg. Co.

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Hommel, O., Co., Inc.

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Norton Co.

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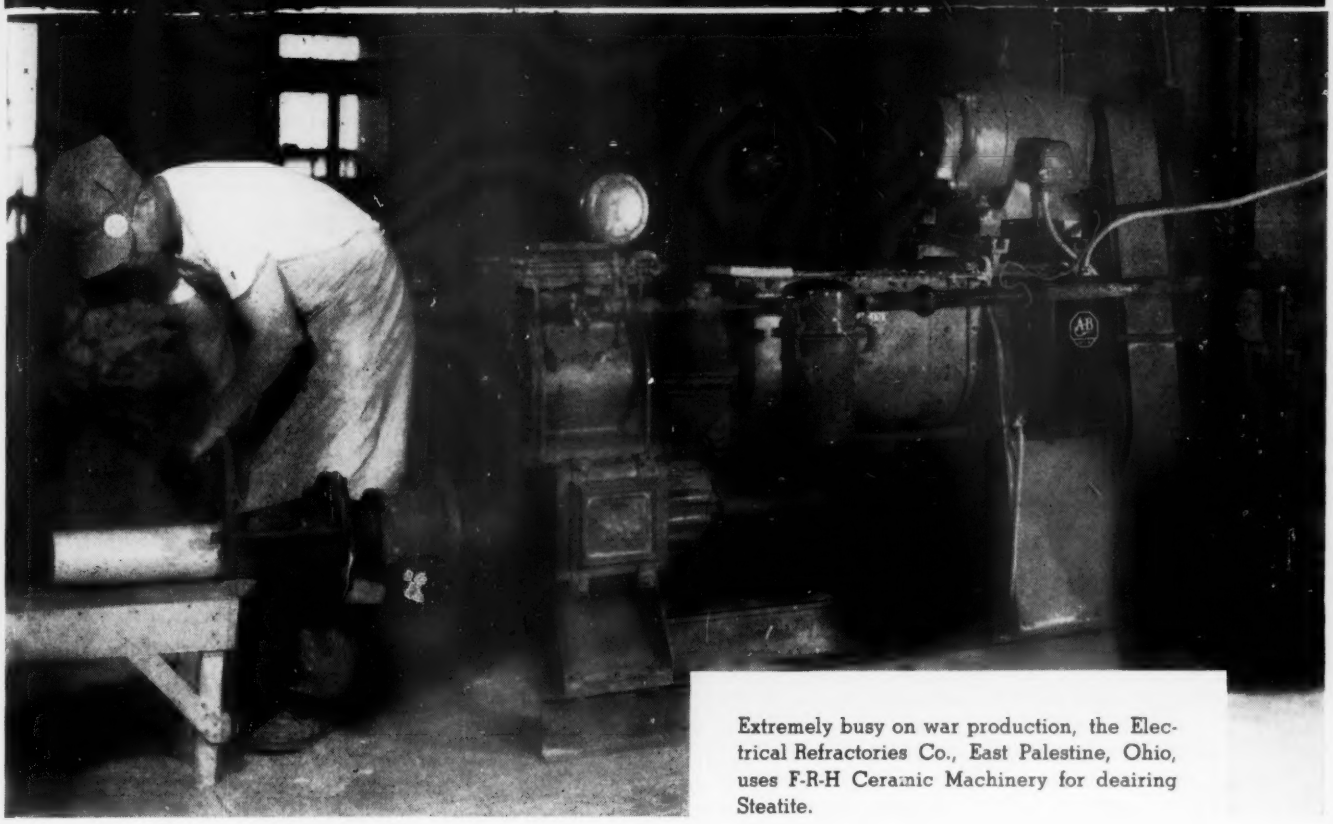

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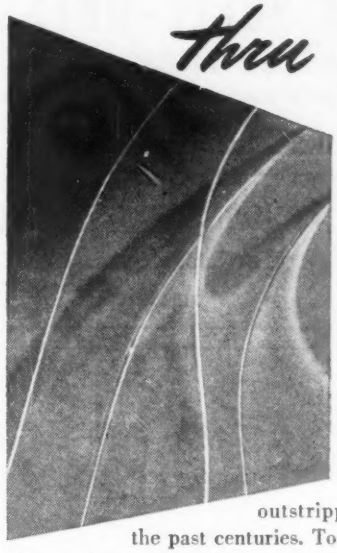

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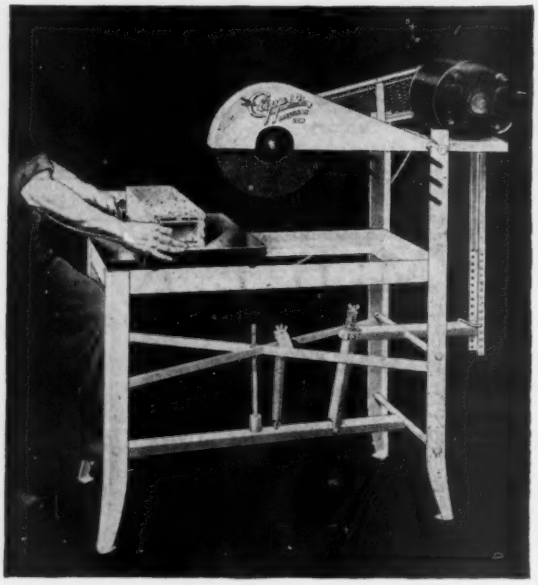
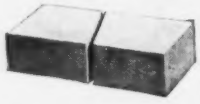
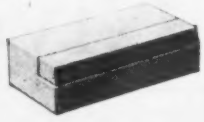


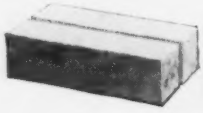
The new Clipper Multiple Cutting Principle makes possible faster cutting of every masonry material regardless of hardness. Here are a few typical examples:



This acid brick intended for a chemical plant acid chamber was cut completely in two, in just 37 seconds.

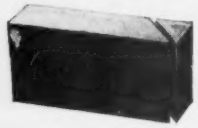
One of many intricate cuts performed on first quality clay brick for heat treating furnaces. Made in 8 sec.





Silica brick cut lengthwise for open hearth furnace work, only 9 seconds were required to complete this cut!

Basic refractories for steel furnaces or cement kilns must be accurately installed. This magnesite brick was cut in 12 seconds.



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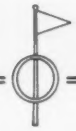

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